# CALIFORNIA GROUND SQUIRRELS

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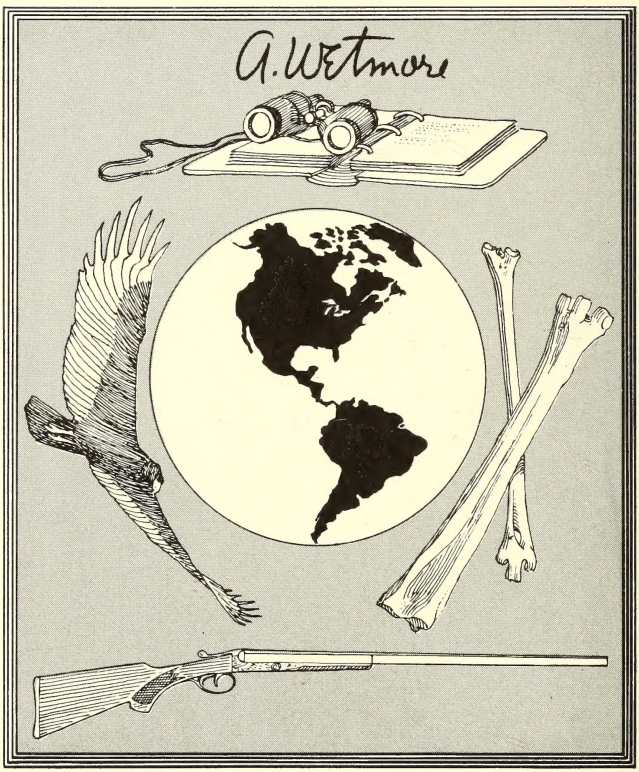


# Alexander Wetmore

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THE MONTHLY BULLETIN

CALIFORNIA STATE COMMISSION OF HORTICULTURE

Volume VII NOVEMBER-DECEMBER, 1918 Nos. 11 and 12

# California Ground Squirrels

## A Bulletin Dealing With Life Histories Habits and Control of the Ground Squirrels in California

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THE RODENT CONTROL DIVISION

W. C. JACOBSEN, Superintendent - - - Editor
S. V. CHRISTIERSON, Asst. Superintendent, Associate Editor

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# THE MONTHLY BULLETIN.

CALIFORNIA STATE COMMISSION OF HORTICULTURE

Vol. VII NOVEMBER-DECEMBER, 1918 Nos. 11-12

## FOREWORD.

The engrossing question in the public mind today—that of reconstruction—must be studied closely in the United States with a view to the immediate prevention of industrial demoralization and social distress, which may react, unfortunately, to a greater or lesser degree, as the truly normal penalty of extraordinary and extended exertion incidental to the great war.

No less an event than the colossal world conflict, which has expired by virtue of its very intensity, could have demonstrated so forcibly the absolute dependence of all phases of industrial life upon the single industry—agriculture.

And industry, we know, is the lifeblood of all people and of all nations!

Thus it has remained for this war strongly to throw the light of universal recognition upon agriculture and its associated activities, as the one, primal, all-essential requisite in the successful prosecution of any enterprise, be it war or peace.

With the increased emphasis placed upon the promotion of agriculture as a "munition of war," there has appeared a correspondingly grave realization of the necessity of further reducing those losses which under certain conditions with adequate means for repression may be made so largely preventable.

The vast economic loss visited upon the agricultural interests of California by rodents was keenly appreciated by the State Commissioner of Horticulture and vested by virtue of his office with the duty "to promote and protect the plant industry of the state," he sought and obtained the deep interest and the active support of Governor Wm. D. Stephens and the members of the California State Board of Control. These gentlemen became fully convinced of the gravity of the situation, by the indisputable array of facts and figures testifying to the ravages of these destructive rodents and gave the support and provided the means needed to inaugurate an energetic state-wide campaign to control the rodent pests. For the purpose of executing the measures involved in this campaign, the State Commissioner of Horticulture organized the Division of Rodent Control, which was to operate under his direct supervision.

An early step in the state-wide movement for the destruction of rodent pests was educational campaigns. The farmers of the state already were thoroughly familiar with the losses caused by rodents. There was need, however, for education as to the best methods of control and to bring home to every land owner the fact that not he alone but his neighbors on all sides were engaging in the same operation at the same time.

While there has been available in the past information of more or less value dealing with the life histories, habits and methods of control

of ground squirrels in California, a comprehensive summary embracing all of these methods for control has been lacking. By assembling the salient features of this investigation in a single number of the Monthly Bulletin of the State Commission of Horticulture, such descriptions and measures of control are immediately available, comprising not only a manual for the use of county horticultural commissioners and systematic workers, but a veritable textbook, through the aid of which it is now possible for the agricultural teacher throughout the public schools to place the subject clearly and concisely before the young patriots who are aiding so largely in the work of extermination. Especial care has been exercised that the work be presented in a manner to win the approval of the farmers and horticulturists and it will prove of inestimable educational value to them, since they now have come to view the depredations of ground squirrels as a truly serious and expensive avenue of loss.

The effectiveness of the work of the Rodent Control Division of the State Commission of Horticulture has been increased materially through the efforts of Mr. E. W. Nelson, chief of the Bureau of Biological Survey, United States Department of Agriculture, and Mr. F. E. Garlough, biological assistant of the same bureau, and credit is also due for the aid accorded by Dr. W. C. Billings of the United States Public Health Service.

Untiring and enthusiastic support has been given throughout California by many county horticultural commissioners who have contributed to the work.

For the detailed study of the life histories and habits of the species we are especially indebted to Dr. Joseph Grinnell, director of the museum, to Mr. Joseph Dixon, curator of mammals, and other members of the staff of the Museum of Vertebrate Zoology of the University of California.

Professor W. T. Shaw, zoologist, Washington State College, will be appreciated for his special study of the Columbian ground squirrel, and we extend our thanks to Professor John S. Burd of the University of California for his able and timely contribution.

Expressions of appreciation are due, for the services rendered by the Rodent Control Division especially through the work of Mr. Jacobsen, the superintendent, and Mr. Christierson, the assistant superintendent, through whose untiring efforts the success of the rodent campaign was so largely determined and assured.

The State Commissioner of Horticulture now offers to the interested public and the horticultural interests of California the composite results of the work against the destructive ground squirrels of California. The campaign which started as one of repression, or at best control, must assume, in the future proportions well calculated almost to mean extermination, and while the work at times was beset with innumerable obstacles, with the earnest, whole-hearted support accorded by all factors throughout the campaign, we may rest in the realization that we have fought a good fight, and based on the scope of activities as determined by the resources at our command, we have been successful.

G. H. HECKE,
*State Commissioner of Horticulture.*

# NATURAL HISTORY OF THE GROUND SQUIRRELS OF CALIFORNIA.

By JOSEPH GRINNELL and JOSEPH DIXON.

Contribution from the Museum of Vertebrate Zoology, of the University of California.

## INTRODUCTION.

Human occupancy of a new country always tends to upset the primitive balance of things. Man either purposefully or incidentally begins at once to modify the original complement of animal and plant life both through destruction of native species and by bringing in with him alien kinds. Some native species become more and more restricted in range, even disappearing altogether; others tend to increase and spread, finding conditions for their existence to be improved through man's activities.

In the case of the ground squirrels of California, we have a group of mammals which seems to have in many places benefited by human invasion. This is probably due to the destruction by man of the many predatory animals, such as hawks, eagles, coyotes and badgers, which under original conditions kept the small herbivorous mammals in check, and in part to the improved food supply made available to the ground squirrels through his cultivation of crops. Because of the destructiveness of these rodents to the planted crops and native forage upon which man is dependent to a large extent directly or indirectly for his own food supply, the problem of ground squirrel control has become one of very immediate agricultural and pastoral importance.

It would seem that knowledge, as full as possible, of the ground squirrels of California is necessary to determining the most successful means of controlling them and to applying these means properly to the varying conditions throughout our state. This knowledge should include the main distinctions by which each may be known from its relatives, the distribution of each of the species, the extent of the burrows, the breeding rate, the food habits, and, indeed, every other class of facts obtainable relative to their natural history. It is not often apparent, in advance, which facts will and which will not prove of critical importance in economic work.

To illustrate the value of a thorough knowledge of the food habits of the animal in question, when the most efficient method of controlling destructive rodents is sought, we need only to point to the present method used in poisoning the California Ground Squirrel by the use of barley coated with strychnine, rather than barley soaked in a strychnine solution. By applying a knowledge of the food habits of this animal it was possible greatly to increase the effectiveness of poisoned grain because of the discovery by Stanley E. Piper, of the United States Biological Survey, that this squirrel is more readily poisoned through the membranous walls of its cheek-pouches when merely carrying the poisoned grain than through the stomach after the poisoned grain has been eaten. Strychnine-coated barley has not, however, been found

so successful when applied to the Oregon Ground Squirrel, which animal apparently does not habitually gather and store seeds and grain to a large extent, but is active chiefly during the spring and early summer when green vegetation, upon which it depends for food, is to be had. Some sort of green baits might be expected to be more effective with this species.

It is very desirable at this time that we know more about the extent of æstivation and hibernation among our ground squirrels. We know little or nothing of the effect of gases upon squirrels in this condition; and it is obvious that such part of a squirrel population as is dormant at the time of a poison campaign will escape destruction and become a nucleus of reinfestation.

During the past spring and summer our work of excavating squirrel burrows after the occupants had been gassed, has shown that one frequent cause of failure in the ordinary waste-ball method of applying carbon bisulphid is due to the fact that sudden elevation in the course of the burrow, of as much as two feet in some cases, prevents the heavy gas from reaching the animal. This condition was found to occur much more frequently than is generally supposed.

The instances just cited all suggest that the present knowledge of our ground squirrels is far from complete, and they serve to emphasize the above contention that a more thorough knowledge of this subject is essential to securing the most intelligent and efficient methods of control of these our chief rodent pests. It is the purpose of the present paper to supply the information available from all sources in as much detail as it has proven feasible for the authors to secure it at this time. The facts and inferences are given just as they came, irrespective of whether or not they show obvious and immediate economic bearing. They are here available to everyone who is concerned with *methods* of control.

## ACKNOWLEDGMENTS.

The present paper has been prepared at the suggestion of Mr. G. H. Hecke, California State Commissioner of Horticulture, and Mr. W. C. Jacobsen, Superintendent of Rodent Control under this commission. Both these men have rendered many valuable helps during the progress of our work and have co-operated to facilitate its final publication. Their emphasis all along has been upon the need of a summary of the facts relative to rodent natural history at this particular time, when efforts from every direction are being concentrated upon the problem of increased crop production.

Upon the facilities and auspices of the Museum of Vertebrate Zoology of the University of California the writers have been dependent for the opportunity of carrying through their undertaking; and behind this has been the continual financial and moral support of the founder and constant patron of the Museum, Miss Annie M. Alexander. The collections of specimens and the field records contained in this Museum, gathered during the past ten years, have been absolutely indispensable

to the present accomplishment. A total of 1263 study skins of ground squirrels taken within this state have been examined in the course of our work.

In the spring and summer of 1911, two field assistants from the United States Public Health and Marine-Hospital Service were assigned by Dr. Rupert Blue, then Surgeon in Command, San Francisco, to accompany the Museum party working in south-central California, for the purpose of increasing the common knowledge of the distribution and manner of occurrence of the rodents of the region. Acknowledgment is here made for the use of certain facts from the manuscript report of that year's work made to Dr. Blue by the Director of the Museum.

During the past year, Dr. W. C. Billings, Surgeon, in temporary charge, United States Public Health Service, San Francisco, has very greatly aided us in having his field men send us specimens of ground squirrels, both alive and dead, for experimentation and study.

To Professor Harvey M. Hall, of the University of California, we are indebted for identifying numerous seeds obtained from the cheek-pouches of ground squirrels.

Through special provision of the State Commissioner of Horticulture we have been fortunate in being able to have the accompanying five colored plates of ground squirrels drawn by the eminent animal artist, Mr. Louis Agassiz Fuertes. We thank Mr. Fuertes for the special pains he has taken in executing these drawings.

Color terms used in our descriptions are taken from Ridgway's *Color Standards and Color Nomenclature* (1912).

Information used by us from published sources is credited through the system of author, year and page references to the list of "Literature Cited" which appears at the end of this paper. The authority for important information obtained from field notebooks or from letters is given in parenthesis together with the abbreviation for the word manuscript—"MS."

JOSEPH GRINNELL.
JOSEPH DIXON.

*September 13, 1918.*

# KEY TO THE GROUND SQUIRRELS OF CALIFORNIA.

1. Size large: body alone more than 9 inches (228 mm.) long; tail more than 6 inches (152 mm.), not counting hairs; ears tall and rather pointed; tail bushy.
   2. A blackish brown wedge-shaped patch on middle of back between shoulders ---------- **Douglas Ground Squirrel** (p. 52).
   2′. No blackish patch on back.
      3. Tail longer: without hairs, about 8 inches (203 mm.); no sharply defined triangular whitish patch on each shoulder---------- **Rock Squirrel** (p. 58).
      3′. Tail shorter: without hairs, 7½ inches (190 mm.) or less; a more or less sharply defined triangular whitish patch on each shoulder.
         4. Size larger: body alone more than 10¾ inches (273 mm.) long; general tone of coloration darker------ **Catalina Island Ground Squirrel** (p. 49).
         4′. Size smaller: body alone less than 10¾ inches (273 mm.); general tone of coloration lighter.
            5. Coloration pale in general tone, near light cinnamon-drab; shoulder patches clear silvery white and more extensive---------- **Fisher Ground Squirrel** (p. 44).
            5′. Coloration somewhat darker, near wood brown; shoulder patches duller white and less extensive--- **California Ground Squirrel** (p. 9).

1′. Size medium or small: body alone less than 9 inches (228 mm.); tail less than 6 inches (152 mm.), not bushy; ears low and rounded, or else reduced to mere rims.
   6. Body with conspicuous lengthwise stripes; coloration varied.
      7. One white stripe on each side of body; under side of tail conspicuously white; head not more or less yellowish or coppery.
         8. Smaller: body alone 6 inches (152 mm.) or less; general coloration grayish drab---------- **Desert Antelope Ground Squirrel** (p. 94).
         8′. Larger: body alone 6¼ inches (158 mm.) or more; general coloration light clay color.
            9. Size slightly greater; tone of color slightly darker, more deeply clay color---------- **Nelson Antelope Ground Squirrel** (p. 103).
            9′. Size slightly less; tone of color slightly paler, more buffy---------- **Los Baños Antelope Ground Squirrel** (p. 110).
      7′. Three stripes on each side of body, one white and two black; head more or less yellowish or coppery.
         10. Tail longer: without hairs, about 3½ inches (89 mm.).
            11. Tone of coloration lighter; middle of back more of an ashy brown ---------- **Inyo Golden-mantled Ground Squirrel** (p. 89).
            11′. Tone of coloration darker; middle of back more of a cinnamon-brown---------- **Sierra Golden-mantled Ground Squirrel** (p. 83).
         10′. Tail shorter: without hairs, about 3⅛ inches (79 mm.)---------- **San Bernardino Golden-mantled Ground Squirrel** (p. 92).
   6′. Body without any stripes: general coloration nearly or quite uniform.
      12. Size larger: body alone more than 7 inches (178 mm.).
         13. Larger: body about 8½ inches (216 mm.); middle of back not bright reddish-brown, but grayish-brown--- **Oregon Ground Squirrel** (p. 59).
         13′. Smaller: body about 7⅞ inches (198 mm.); middle of back bright reddish-brown---------- **Belding Ground Squirrel** (p. 67).
      12′. Size smaller: body alone less than 7 inches (178 mm.).
         14. Tail round and relatively long: over 3 inches (76 mm.).
            15. Tone of coloration paler, light pinkish-cinnamon---------- **Yuma Round-tailed Ground Squirrel** (p. 76).
            15′. Tone of coloration darker, wood brown---------- **Death Valley Round-tailed Ground Squirrel** (p. 80).
            15″. Tone of coloration medium, grayish-brown or avellaneous-- **Palm Springs Round-tailed Ground Squirrel** (p. 81).
         14′. Tail flat-haired and relatively short: under 3 inches (76 mm.).
            16. Under side of tail pinkish-buff; rim of ear distinct though low ---------- **Stephens Soft-haired Ground Squirrel** (p. 73).
            16′. Under side of tail white; rim of ear scarcely discernible above general surface of head--------- **Mohave Ground Squirrel** (p. 75).

NOTE.—Figures indicating page numbers refer to folios at foot of pages.

CALIFORNIA (OR BEECHEY) GROUND SQUIRRELS.

## CALIFORNIA GROUND SQUIRREL.

### Citellus beecheyi beecheyi (Richardson).

PLATE I.

**Other names.**—Digger Squirrel, part; Beechey Ground Squirrel; Beechey's Marmot; Beechey Spermophile; *Spermophilus beecheyi*, part; *Arctomys beecheyi; Spermophilus grammurus beecheyi*, part; *Citellus variegatus beecheyi; Citellus grammurus beecheyi; Otospermophilus beecheyi.*

**Field characters.**—A large ground-dwelling squirrel, with long bushy tail, good-sized ears, and general brownish coloration; dull whitish area on side of neck and shoulder, and fine dappled pattern of coloration on back and sides, to be seen in close view. Length of body alone about 10½ inches, with tail (without hairs) about 6½ inches more.

**Description.**—Adults in summer pelage: Top of head, stripe down middle of hind neck, whole back, sides, and rump, of a general wood brown tone of coloration, but variegated in fine pattern on back, rump and sides by mottlings of snuff brown and buffy white; these mottlings usually line up in transverse rows, the rows being most distinct across the rump; a large area centering on side of neck and involving

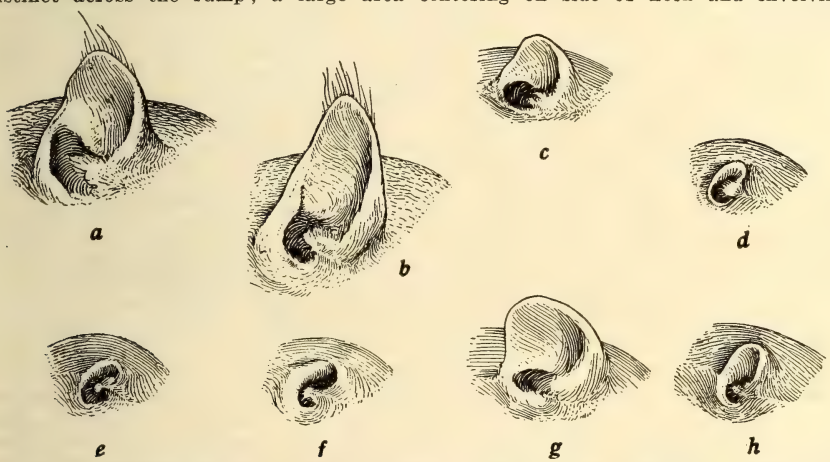


FIG. 1. Ears of ground squirrels to show characters of size and shape in different species. *a*, California Ground Squirrel; *b*, Fisher Ground Squirrel; *c*, Oregon Ground Squirrel; *d*, Stephens Soft-haired Ground Squirrel; *e*, Mohave Ground Squirrel; *f*, Yuma Round-tailed Ground Squirrel; *g*, Sierra Golden-mantled Ground Squirrel; *h*, Desert Antelope Ground Squirrel. All natural size and drawn direct from specimens. Note: *a* and *b* are extreme examples; the average difference existing between the California and the Fisher ground squirrels is much less; individuals of each race can be found which will overlap some individuals of the other in size and shape.

shoulder, and a faint stripe backward a short distance from upper margin of this area, dull white. Cheeks dirty white, changing to wood brown color between eye and ear; eyelids white; whiskers black. Ears tall and conspicuous, finely haired; color of ear inside, pale pinkish buff; back of ear, front half, black, becoming dull cinnamon buff at base and on hinder margin; fine black hairs extending above rim at tip of ear sometimes so numerous and long as to form a small tuft; whole lower surface of body, inner sides of fore and hind legs, and upper sides of feet, pinkish buff; hairs of breast and belly gray at base, this resulting in a darker tone on this area. Palms of fore feet naked; soles of hind feet thinly haired behind tubercles, or else wholly naked, due apparently to wearing away of the hairs altogether; claws brownish black, horn-color toward tips. Tail bushy, though not nearly so much so as in the tree squirrels, flat haired, parallel-sided, and square or round ended; hairs along sides of tail about 41 mm. (1⅝ inches) long, at end of tail the same; general color of tail both above and below buffy grizzled gray, in other words mixed black and buffy white in

fine pattern; the buff tone is deeper below than above; close inspection shows the hairing of the tail to be concentrically banded, three black bands and four light ones, the outermost black band being broadest, and the outermost light one constituting a peripheral whitish fringe.

**Color variations.**—As far as we can see, the two sexes are identical in coloration, save as caused by the greater rate of wear to which the pelage of the female is subject during the season when the young are being reared. Wear progresses in some cases until most of the colored ends of the hairs are gone, and a dingy light brown color is acquired, including also the tail. Molting begins anteriorly and progresses backward.

The material we have studied seems to show but one decided molt in adults each year, and this takes place during July and August. Young, however, seem to undergo two molts in the first six months of their lives. When one-third grown their pelage is characterized by a fluffy texture and a yellowish tone of color, but the general pattern is closely similar to that of adults; when nearly full grown the young are smooth-coated and show rather brighter tones of brown and clearer white shoulder patches that even fresh-pelaged adults.

There are not infrequent special, or "sport" variations, in the Beechey Ground Squirrel, such as albinos, either complete or partial, which have been reported from time to time. We have been told of "black" ground squirrels; and there is in the Museum of Vertebrate Zoology an adult male, from Stanislaus County, taken by W. C. Jacobsen, January 30, 1918, which is of a curious light pinkish-buff tone of coloration, save for the outermost concentric black band on the tail and for the whitish shoulder patches and a suggestion of dappling on the back.

The color description given above was taken from specimens from the vicinity of San Francisco Bay. Specimens from other parts of the general range of the Beechey Ground Squirrel depart from this slightly in different respects. Two specimens at hand from Marysville Buttes, Sutter County, are of paler, grayer tone of general color. A series of skins from the western slope of the central Sierra Nevada averages whiter underneath and darker brown on middle of back. Examples from the southern San Joaquin Valley are paler in tone of coloration and exhibit whiter shoulder patches, thus evidently constituting intergrades towards the Fisher Ground Squirrel. A series from the coast district of southern California, from Santa Barbara to San Diego, shows darker brown back, but whiter under surface of body, and the white shoulder patches are more conspicuously contrasted. Some San Diego County examples in rather worn pelage show a curious reddish tinge on the rump.

**Measurements.**[1]—Average and extreme measurements, in millimeters, of twenty full-grown specimens from west-central California are as follows: Ten males: total length, 435 (405–475); tail vertebræ, 164 (150–175); hind foot, 57 (52–60); ear from crown, 20.5 (17–24); greatest length of skull, 59.1 (56.9–61.1); zygomatic breadth, 36.9 (35.0–39.2); interorbital width, 14.1 (13.3–15.0). Ten females: total length, 423 (400–460); tail vertebræ, 162 (150–175); hind foot, 57 (55–58); ear from crown, 18.4 (16–20); greatest length of skull, 56.2 (53.8–59.5); zygomatic breadth, 35.8 (34.3–37.6); interorbital width, 13.9 (13.0–14.7).

It will be seen from the above figures that females are decidedly smaller bodied than males though in tail length they are about the same. The skulls of the oldest individuals, particularly males, show greatest general size, greatest zygomatic breadth (as

[1]The measurements given throughout the present paper have been taken according to the following methods. The external dimensions are those recorded on the label attached to the skin and were taken from the freshly killed animal by the collector in each case. *Total length* is the distance from the tip of the nose to the tip of the last vertebra of the tail (which is also practically the tip of the tail without the hairs), the body and tail being straightened out but not stretched; *tail vertebræ* is the length of the tail alone (again without hairs), from a point on upper side at base where tail can be bent at right angles to back, to tip of last vertebra; *hind foot* is measured when extended flat at right angles to leg, from heel to tip of longest claw; *ear from crown* is the distance vertically from top of head at inner base of ear to extreme tip of ear, not including hairs. The cranial measurements were all taken by the senior author, with parallel calipers reading to tenths of millimeters, from cleaned skulls. *Greatest length of skull* is taken parallel to axis of skull from anterior tips of nasals to most posterior point or points on skull (this in some skulls falls on the condyles, in some on the lambdoidal ridge); *zygomatic width* is the greatest width of skull at right angles to axis, from the outer surface of one zygomatic arch to the outer surface of the other; *interorbital width* is the least distance between the eye-sockets, but not counting the little notch usually present in ground squirrels on each edge of the interorbital portion of the roof of the skull.

compared with total length of skull), broadest jugals, stoutest postorbital processes, highest developed sagittal crest, most nearly approaching parietal ridges (these meeting also farthest forward), and broadest frontal region (which also shows a concave or "dished" upper surface). In other words, old animals have skulls which are more massive and angular than those of young ones. We find that relative age of an individual can be recognized approximately by the relative degree of development of the above characters. Amount of wear on the crowns of the molariform teeth and of advance in coalescence of the contiguous bones along certain sutures also give criteria for determination of age.

**Weights.**—Average and extreme weights, in grams, of twenty full-grown specimens from west-central California are as follows: Ten males, 696 (600–923); ten females, 592 (491–774). Averages in ounces: males, about 24 (1½ pounds); females, about 20 (1¼ pounds).

It appears that males are 17 per cent heavier than females. The heaviest specimen out of a total of 36 weighed, was an old male tipping the scales at 923 grams, or 32½ ounces, or a trifle over two pounds. This animal was shot June 12, 1918, in a slaughter yard at Mendota, and was exceedingly fat.

**Type locality.**—"Neighborhood of San Francisco and Monterey" (Richardson, 1829, p. 170).

**Distribution area.**—The greater part of central and southern California west of the desert divides. Altitudinally, ranges from sea-level up regularly to about 6,000 feet, and locally and sparsely to as high as 8,200 feet (in Yosemite National Park). As regards life-zone, the California Ground Squirrel is most abundant in the Upper Sonoran zone, less so in the Lower Sonoran and Transition, and but relatively rare and local in Canadian (see fig. 23).

More in detail, this squirrel is limited to the northward in the coast belt abruptly at the south sides of the Golden Gate, San Francisco Bay, Carquinez Strait, and Suisun Bay. Its range extends northward over the eastern half of the Sacramento Valley to the Marysville Buttes and its limits thence swing northeastwardly through the Feather River country to the southern border of Lassen County. From this last point south it covers both slopes of the Sierras nearly to the Yosemite region, but thence south to Tulare County, only the western slope. In the vicinity of Lake Tahoe it gets a little way into the state of Nevada. To the southward it covers most of the San Joaquin Valley, and the coast belt south throughout the San Diegan district to the Mexican border, and beyond this even to the San Pedro Martir mountains.

Along the eastern border of its range, from Tulare County south to Riverside County, the race *beecheyi* grades into the race *fisheri*. The dotted line on the map (fig. 17) marks approximately the center of the area of intergradation between the two races. As will be seen, the limits of *beecheyi* swing west across the southern San Joaquin Valley and thence around south so as to exclude the Bakersfield region and the Tehachapi, Tejon, San Bernardino and San Jacinto mountains.

**Specimens examined.**—A total of 149 specimens from the following localities in California: San Francisco County: Ingleside Race-track, 1. Alameda County: vicinity of Berkeley, 9. Contra Costa County: Walnut Creek, 12; west side Mount Diablo, 2. San Mateo County: Sierra Morena, 1; Pescadero Creek, 1. Santa Clara County: Palo Alto, 1. San Benito County: Cook, 2. Monterey County: Monterey, 6. Sutter County: Marysville Buttes, 2. Stanislaus County: Claribell Station, 1. San Joaquin County: eight miles southwest of Tracy, 1. Sierra County: near Sierraville, 1. Placer County: Dutch Flat, 1; Blue Canyon, 1; Cisco, 2. El Dorado County: Fallen Leaf Lake, 1; Kyburz Station, 2. Tuolumne County: Aspen Valley, 6,400 ft., 1. Mariposa County: Merced Grove, 1; Crane Flat, 6,300 ft., 1; Indian Creek, 6,100 ft., 1; Yosemite Valley, 3; Merced Lake, 7,500 ft., 2; Mono Meadow, 7,300 ft., 1; Chinquapin, 6,200 ft., 1; El Portal, 2,000 ft., 2; Coulterville, 2; Pleasant Valley, 1. Merced County: Snelling, 1; Los Baños, 1. Madera County: Raymond, 2. Fresno County: Mendota, 4; Panoche Creek, at 502 ft., 1; Friant, 1; Kings River, 5,000 ft., 2. Ventura County: Matilija, 4; Ventura, 3. Los Angeles County: vicinity of Pasadena, 7; near Azusa, 2. San Bernardino County: near Colton, 4. Riverside County: Thomas Mountain, 6,800 ft., 1. San Diego County: Warner Pass, 3; Grapevine Spring, 1; Witch Creek, 8; Julian, 8; Cuyamaca Mountains, 4; San Diego, 2; Point Loma, 10; Chula Vista, 3; near mouth Tiajuana River, 1; Dulzura, 7; Campo, 1; Jacumba, 1; Mounta'n Spring, 4.

The California Ground Squirrel is probably known by sight to more people than any other one of our four hundred kinds of native mammals. It inhabits open ground in well-settled territory and it forages abroad during the daylight hours when its movements are most likely to attract attention. Numbers are to be seen from the windows of passing trains, and the traveller by automobile is often thrilled by the narrow escapes of those heedless individuals which dash across the road immediately in advance of him, not infrequently to their own undoing. Then, too, this squirrel has, perhaps, been more widely advertised than any of our other mammals. A few years ago it came into prominence as a proven disseminator of the dreaded bubonic plague, and it has become notorious for its exceeding destructiveness to cultivated crops.

The term "Digger Squirrel" is often applied to this species, more especially in the foothill and mountain regions, in recognition of its burrowing habits, to distinguish it from the tree-inhabiting gray and red squirrels. The book name, Beechey Ground Squirrel, much used in the literature relating to it, is derived from the accepted scientific name *Citellus beecheyi*. This name, *beecheyi*, was bestowed upon the animal by its original describer (Richardson, 1829, p. 170) "in honour of the able and scientific Commander of the Blossom," Captain F. W. Beechey. The British ship "Blossom" cruised the Pacific Ocean northward even to Bering Strait during the years 1825 to 1828. Collections of specimens were brought back from many localities visited, including San Francisco and Monterey; among these specimens was one or more of the squirrels in question. These were evidently preserved for the most part by Mr. Collie, surgeon of the ship, who is quoted by Richardson as stating that "this kind of Spermophile 'burrows in great numbers in the sandy declivities and dry plains in the neighbourhood of San Francisco and Monterey, in California, close to the houses. They frequently stand up on their hind legs when looking round about them. In running, they carry the tail generally straight out, but when passing over any little inequality, it is raised, as if to prevent it being soiled. In rainy weather, and when the fields are wet and dirty, they come out but little above ground.'" And further information is given, according, for the most part, with what anyone can see for himself today in the same general region. This attests to the acuteness of observation of Mr. Collie, and also shows how the squirrels had already, some ninety years ago, begun to impress people with their numbers and boldness.

The California Ground Squirrel may be distinguished from other members of the squirrel family by the combination in it of the following characters: essentially ground-dwelling habits, relatively large size, long bushy tail, tall pointed ears, and generally grayish coloration with a three-cornered silvery white patch on each shoulder. Close inspection discloses a finely dappled pattern of coloration (see Fig. 2) such as is not shown in any tree squirrel or in any of our other ground squirrels except its near relatives, the Douglas, Fisher, Rock and Catalina Island squirrels. The detailed descriptions, measurements, etc., as given in the accompanying small-type paragraphs, should be studied for further particulars in this connection.

FIG. 2. A typical example of the California Ground Squirrel, the rodent of chief economic importance in the state. Note the tall, rather pointed ears, the whitish eyelids, the grizzled-white shoulder patch, the mottled back and rump, and the bushy tall. Photographed from life by J. Dixon.

The species now under discussion is restricted in its distribution mainly to the state of California. It extends a little ways south into Lower California; and to the eastward it barely crosses the Nevada line in the vicinity of Lake Tahoe. To the northward in the coast belt it is cut off sharply by the Golden Gate and San Francisco Bay, but in the interior it extends to the headwaters of the Feather River. Southeastwardly toward the deserts the race *beecheyi* blends into the race *fisheri,* which in turn is wholly cut off by the hottest deserts beyond. (See map, fig. 17.) In the coast belt north of San Francisco Bay and from the upper Sacramento Valley northward the Beechey Squirrel is replaced by the Douglas Ground Squirrel.

Altitudinally the California Ground Squirrel ranges from sea level, as on the shores of Monterey Bay, up to an altitude of at least 8200 feet, as in the Yosemite National Park. It is most abundant on the plains of the San Joaquin and in the Coast Ranges and Sierra foothills. As regards life-zone, the metropolis of the species lies in the Lower and Upper Sonoran (see fig. 23). It is less numerous in the yellow pine belt (Transition zone), and is but rarely or sparingly represented in the Canadian zone, still higher on the mountains. Its preferences as to local conditions are not closely limited, except that it avoids dense chaparral and thick woods. It frequents pasture lands, grain fields, orchards, sparsely tree-covered slopes, small mountain meadows, rock outcrops on the tops of ridges, and even granite talus slopes. It is always most abundant, however, in the open situations, and its decided preferences are such that it thickly populates much of the best farming and grazing lands in the state, to the great reduction of their producing value from the human standpoint.

This squirrel secures shelter for itself and young, and safety from its enemies, by burrowing in the ground. Where possible it chooses to excavate its retreats in hillsides or in low earth banks. Here some at least of the necessary digging can be done in a horizontal direction. But, of course, those members of the species which live on the plains or on small flats or meadows in the foothills or mountains must dig down vertically for considerable distances to gain the requisite protection. Many of the squirrels which live in the granite country make their homes under large boulders or in rock taluses where a minimum of burrowing is necessary to insure safe retreats. On wooded hillsides special safety from enemies that dig is secured by location of the burrows under tree-roots or old stumps.

In the foothill region at the southern end of the San Joaquin Valley there seems to be a decided tendency on the part of the ground squirrel to select alluvial fans for home sites. This preference may be accounted for by the fact that the plants upon which the squirrel feeds make a better growth in the deep alluvial soil there than they do on the adjoining hillsides which are often steep and with but shallow cover of soil. For the same reason the alluvial fans afford easier digging to considerable depth and hence better protection. In seven burrows in different localities, in which the squirrels were gassed and then dug out (J. Dixon, MS), the extent, diameter and depth were found to vary and to depend largely upon the nature of the soil. In shallow adobe or clayey soil, underlaid by broken rock, the burrows were found to be short, of

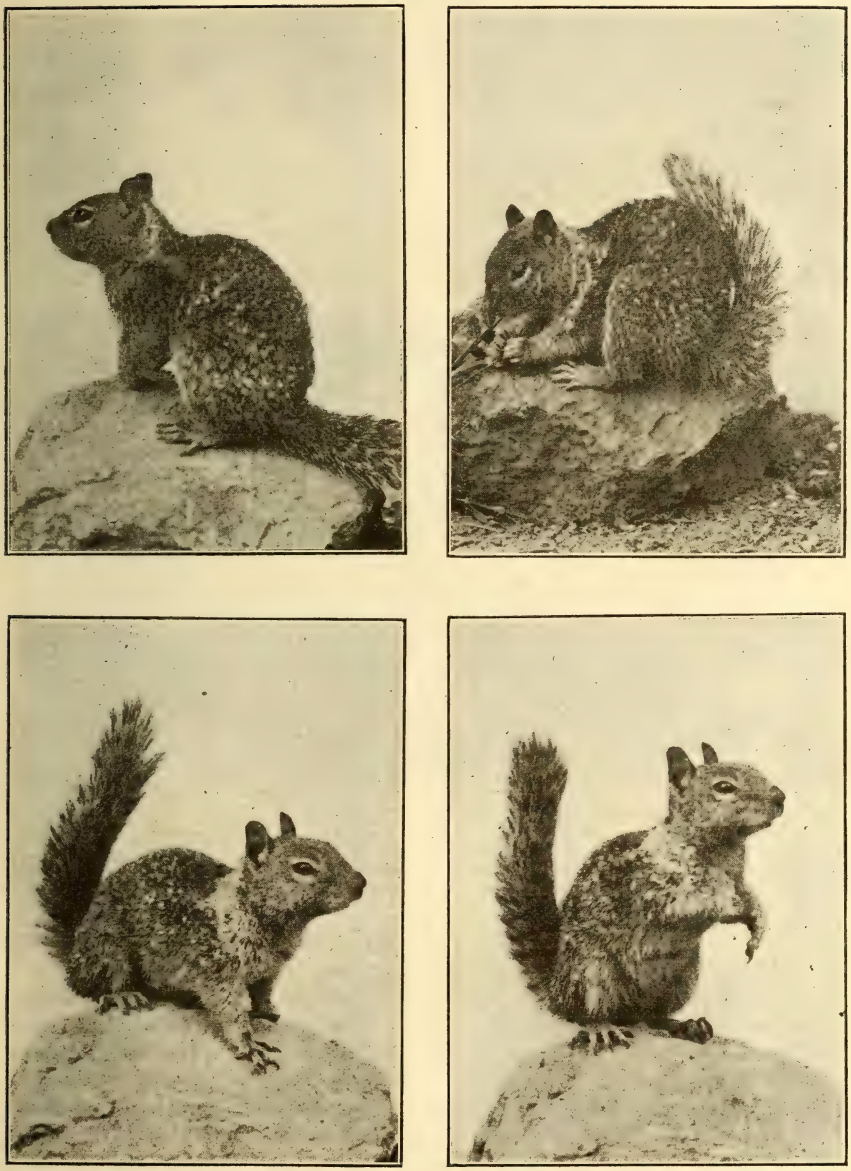

FIG. 3. Four characteristic poses of a California Ground Squirrel. Photographed by J. Dixon at Berkeley in August, 1918.

small diameter, and not reaching to any considerable depth. Those in alluvial or sandy soil were found to be of large diameter, of greater extent, and to reach to much greater depths.

The most conspicuous signs of activity on the part of ground squirrels in any locality are the large mounds of earth that have accumulated in the course of excavating the burrows. This earth is commonly thrown out in a fan-shaped pile directly in front of, and to the sides of, the main entrance to the burrow (see fig. 4). These mounds of earth are often three or four feet in diameter and from six to ten inches above the general level. They vary greatly in size, but average larger in sandy soil than in clayey or rocky ground. The size of the mound is, however, no reliable index to the length or size of the burrow except in those cases where the burrow is of a straight or simple pattern. In

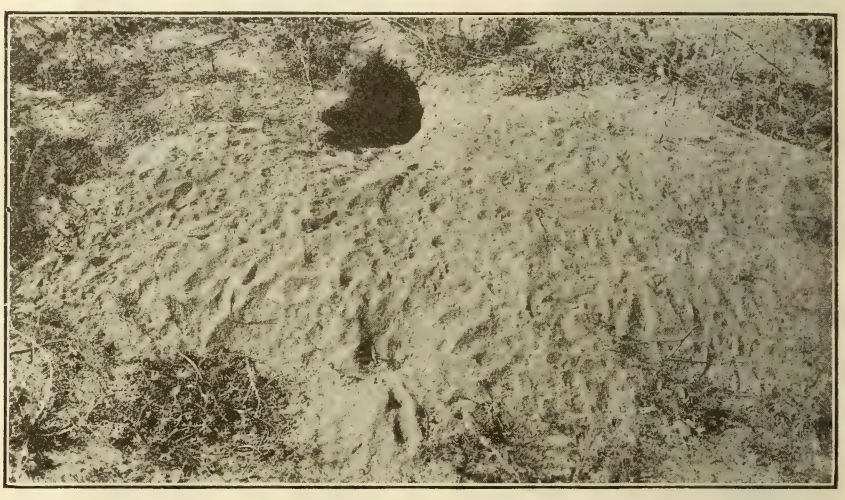

FIG. 4. Mound and burrow entrance of a "digger" squirrel, in sandy ground. Mounds of earth such as these are often three or four feet in diameter and rise from six to ten inches above the general level. The route taken to the feeding grounds being used at this particular time is indicated by the numerous tracks at the left-hand side of the entrance. Photographed at Tipton, Tulare County, May 23, 1918.

colonial or intercommunicating burrows the dirt is not always thrown out at those entrances which allow of the shortest possible "haul."

Most of the work of tunnel excavation is carried on during the spring months, as is shown by the mounds of fresh, soft earth accumulated at the mouths of the burrows in that season. In the lowlands, where there is a large crop of wild oats in the springtime, this newly excavated earth supports a ranker growth than the surrounding parts of the field, so that, as one of our party wrote in his field notes, "the plain looks like a cemetery overgrown with grass," with these taller stands of oats about the squirrel holes suggesting grave mounds.

To some extent the ground squirrels, like the pocket gophers, thus act on wild land as natural cultivators of the soil, and may thus serve a useful purpose. On the other hand, their burrows are frequently the cause of much destructive erosion on hillsides during heavy rainstorms. Numerous small landslides have been noted on steep hillsides

on the campus at Berkeley, that were plainly caused by the presence of squirrel burrows which had concentrated and conducted the water in narrow channels instead of permitting it to spread out and soak in or run off in the natural way. The presence of squirrels along irrigation canals results in the embankments becoming undermined by their burrows, with ensuing disastrous breaks in the canals, especially at times of high water.

Digger Squirrels are firm believers in the daylight saving plan. Their activities above ground are restricted to the hours between sunrise and sunset. They love the warm sunshine and may often be seen sprawled upon the summits of stumps, rocks or other points which afford safety as well, basking in the morning or later afternoon sunshine. During spring and summer they come out of their burrows soon after sun-up. They are at those seasons most active during the middle of the forenoon and again during the late afternoon, but avoid the intensest heat of midday. During midwinter those squirrels which do not remain underground altogether make their appearance only late in the forenoon of bright sunny days. Light and warmth seem to be essential to their successful existence aboveground.

The observer afield often comes upon ground squirrels which are some distance from their holes. Such animals usually run, with bodies and tails undulating and closely paralleling the ground, to the near vicinity of their burrows, where they then post themselves in upright position. They can then watch the intruder, yet be in readiness to dart down into their holes at an instant's warning. While thus on watch a squirrel is wont to repeat, at regular intervals of from two to five seconds, its characteristic "bark." This note is really a double one, and may be indicated by the syllables, *clink-sup.* The second syllable, however, is not audible for any great distance, while the first is loud, staccato, and of decided metallic quality, calling to mind the sound produced by the blow of a light hammer on an anvil. The impression is enhanced by the regularity and frequency of its utterance, and this will be kept up five minutes at a time. Sometimes, when a squirrel is startled, it gives a more prolonged note, *clink-sup-sup-sup-sup,* the last syllables running together as a sort of chuckle. In any event, it is the *clink* which is the metallic syllable, and which one hears a long ways, more or less mellowed by distance.

If closely pressed the squirrels drop down at once into the protection of their subterranean retreats. Ordinarily when thus frightened down they do not reappear at the surface of the ground for some minutes, five to twenty-five minutes in tested cases, as if to give the suspected enemy a chance to tire of his waiting and depart. Occasionally, when surprised at a distance from its burrow, a squirrel will crouch motionless, it may be almost at the feet of the observer, as if to escape detection by the "freezing" ruse. Extreme fear also on occasion may be part of the basis for this mode of behavior.

In some respects the California Ground Squirrel is much "wiser" than is generally supposed. This has been forcibly impressed upon the junior author during his endeavors to secure photographs. Living squirrels were then observed at close range in their various activities under natural conditions. Several species of chipmunk, as well as the Golden-mantled Ground Squirrel and the Nelson Antelope Ground

Squirrel, encountered under the same circumstances, soon became accustomed to the camera so that the photographer, himself at some little distance, was able to release the shutter when the lens of the camera was less than thirty inches from the animal photographed. Compared with this, the Digger Squirrels proved exceedingly wary, refusing to show more than their heads even though the camera was disguised and placed six feet distant. The confidence of the Digger Squirrel could no doubt be gained, given sufficient time; but when an approach was attempted by the methods that had proven successful with the other squirrels the results were nil. It looks as though the reactions of the Digger Squirrel had been adjusted to meet that category of enemies which lie in wait at jumping distance.

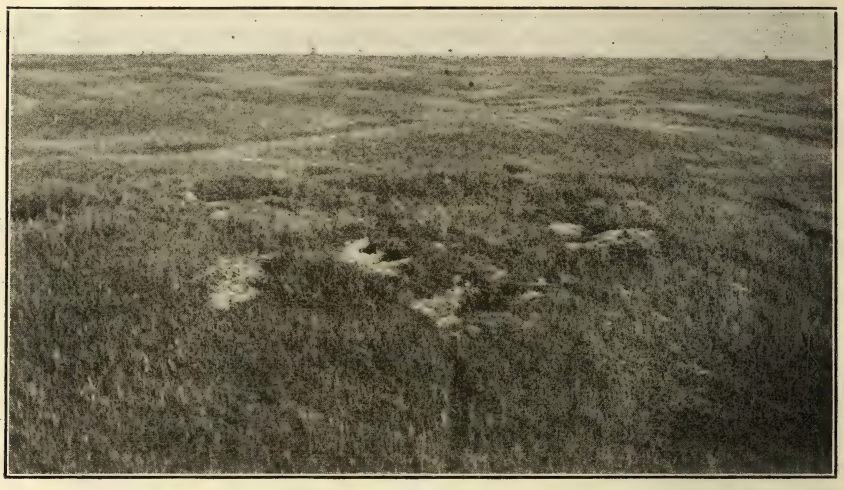

FIG. 5. Typical "hog-wallow" land showing trail and burrows of the California Ground Squirrel. Photographed ten miles north of Fresno, April 10, 1911.

Ground squirrels traveling to and fro, between their holes and their feeding grounds frequently traverse the same courses until regular radiating trails 2½ or 3 inches wide are worn through the grass (see fig. 5). This is particularly well seen on many hillsides, and on the rolling "hog-wallow" lands along the eastern side of the San Joaquin Valley, where, in the fall, when the grass and weeds are dry, the trails show most distinctly. In the spring, when the new growth is just appearing, the trails are still conspicuous, as the vegetation is slower in starting there than in the adjacent unbeaten tracts. Soon, however, the trails are entirely obliterated, save as the animals renew them by further use.

In foraging for seed-pods, grain, or fruits, the ground squirrel does not usually eat the food on the spot where it is gathered, but he stuffs it into his capacious cheek pouches (see fig. 13) or else, if it is too large for this, carries it in his mouth nipped between the incisor teeth. He then repairs to some point of vantage such as a rock pile or to the mound at the entrance of the burrow. Here he proceeds to hull and devour the food at leisure and at the same time is near enough to shelter so that he can quickly duck in should an enemy suddenly appear at

short range. These "husking places" are conspicuously marked by the hulls of seeds and by the rinds and pits of cultivated or wild fruits. Examination of these "kitchen middens" will sometimes give a pretty accurate idea of the character of the squirrels' rations in any locality. A great many of the matured seeds, however, are carried directly below ground to the permanent storehouse.

Droppings, or feces, of the Ground Squirrel are to be observed widely scattered rather than deposited in piles. They may be found about the "husking places" or along the trails or paths which lead from the burrow to the feeding grounds. In the burrows they are accumulated in special places evidently set aside for the purpose. The feces are generally of a cylindrical shape, rounded at the ends, but are quite variable in diameter and volume. In April when green food is abundant fresh feces are of a greenish hue and are often soft and flattened. During the drier portions of the year the droppings are covered with a dark brown coating, while the interior is composed of a dry mass consisting of hulls of weed seeds and finely chopped and shredded vegetable fiber, from 3 to 10 millimeters long. A typical dry dropping measured 16 millimeters ($\frac{5}{8}$ inch) in length, with a diameter of 6 millimeters ($\frac{1}{4}$ inch), and weighed $\frac{1}{10}$ of a gram.

The California Ground Squirrels do not dwell in thickly populated "colonies" of sharply restricted extent, as is the case with the prairie dogs of the Middle West. Still there is with our rodent a tendency to occupy certain definite tracts in a general territory to the exclusion of intervening places and this without obvious reason as regards food

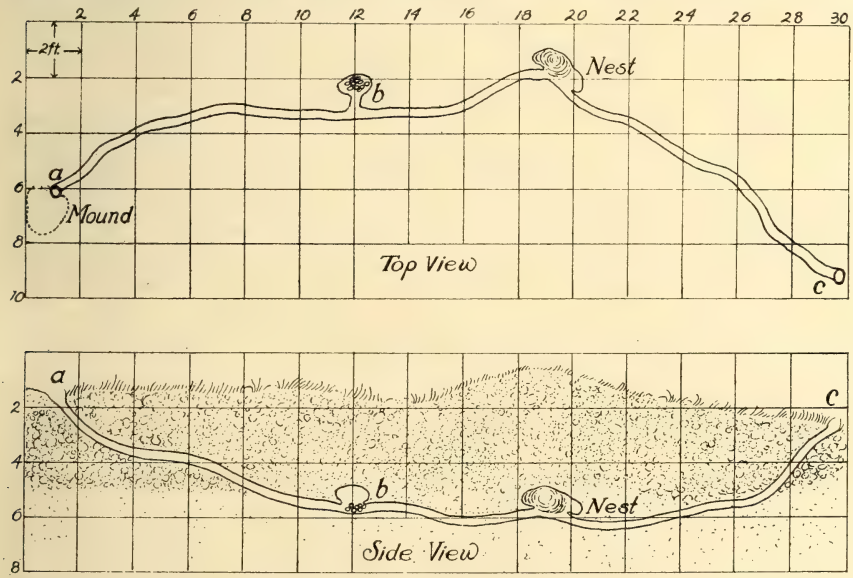


FIG. 6. Plot (plan and elevation) of used burrow of a male "digger" squirrel, as excavated by J. Dixon on an alluvial talus in the foothills near San Emigdio, Kern County, April 28, 1918.

Main entrance at *a*; refuse sump in old nest-cavity at *b*; "blind" exit in thick grass at *c*. Unusual depth of burrow, as shown in profile, was due to thick rock-filled overlying stratum, beneath which the squirrel had found easy digging horizontally after having once penetrated the less resistant part of the layer at the edge of the talus.

Total length of burrow, 34 feet; average diameter, $4\frac{1}{2}$ inches; greatest depth reached, $5\frac{1}{2}$ feet; volumetric contents of entire burrow, $4\frac{3}{4}$ cubic feet.

supply and kind of soil. It would seem that centers of population may arise through the historical circumstance of original settlement by first-comers. This would be particularly the case in fields newly invaded, where descendants would establish their burrows in the near vicinity of their pioneer parents.

Digging operations were carried on by us during the breeding season of the ground squirrel, in quest of all obtainable facts in regard to their habits underground. Three general types of burrows were encountered. The male squirrels were usually found in short, shallow, simple burrows at the outskirts of the "colony." The burrow belonging to a male herewith illustrated (fig. 6) proved to be longer than usual with males,

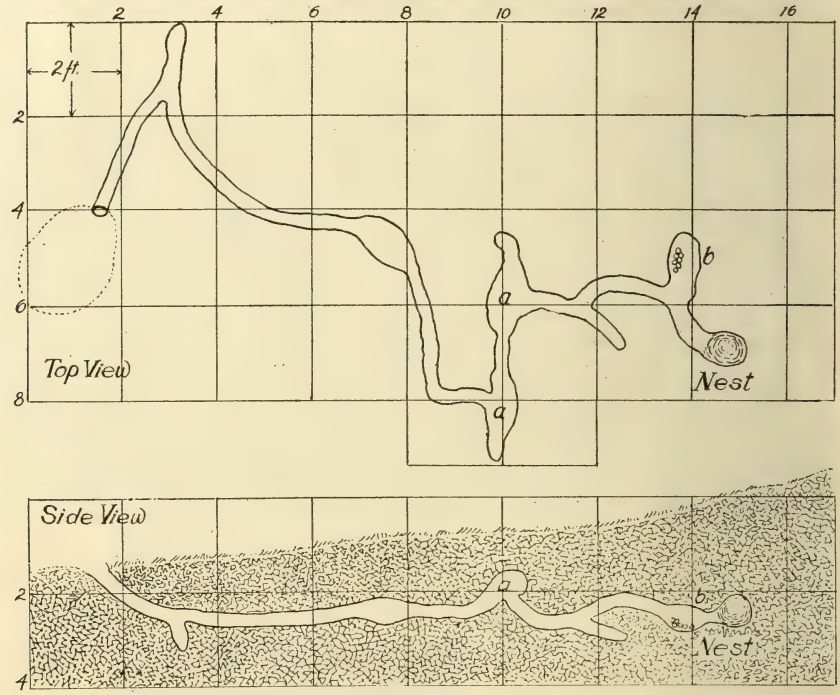


FIG. 7. Plot (plan and elevation) of used nesting burrow of a female "digger" squirrel, as excavated by J. Dixon and G. R. Stewart on a west slope in Strawberry Canyon near Berkeley, April 6, 1918.
Entrance at left; old nest chambers at *a*; refuse sump at *b*; used nest at extreme right, which was found to contain the mother and four small young.
Total length of burrow, 22 feet; average diameter, 4½ inches; greatest depth reached, 30 inches; volumetric content, 4⅝ cubic feet.

and reached to a greater depth, but its simplicity is characteristic for that sex. We failed to secure a single male squirrel in any burrow found to be occupied by a female with young. It is believed that at least during the breeding season the male squirrels live altogether by themselves in their own individual burrows.

A burrow from which a female and four young with eyes still unopened were secured is shown in fig. 7. It will be seen from this illustration that the nest burrow of the female is relatively complicated. This particular burrow was extremely difficult to follow on account of the many turns and "blind alleys."

The third type of burrow (see fig. 8) might well be called a "colonial burrow," as it is used by both sexes and also by the young after these leave the nest burrow and begin to forage for themselves. Colonial burrows are used largely as "safety zones." They afford convenient places for the squirrels to duck into when danger unexpectedly appears. These burrows are often from 100 to 200 feet in length and form a communicating system of underground runways connecting from six to twenty entrances or surface openings. The nests in the colonial burrows were old and had the appearance of having been used by many

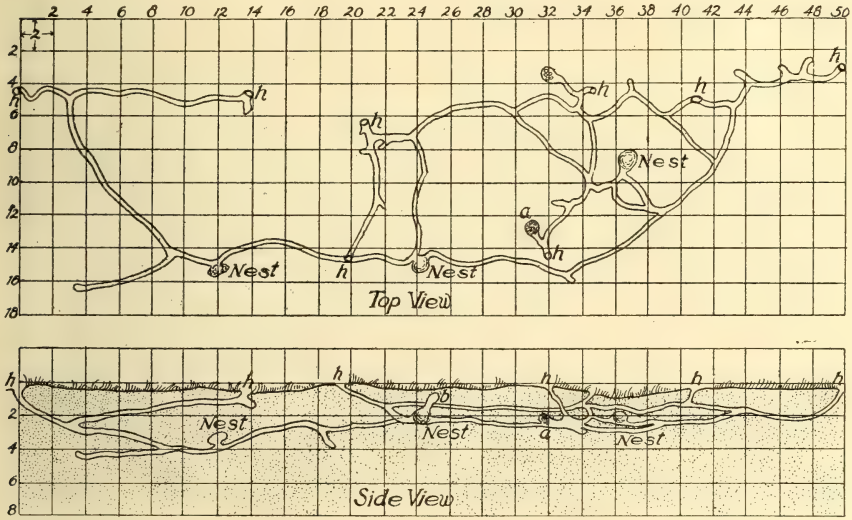


FIG. 8. Plot (plan and elevation) of a "colonial" burrow-system of "digger" squirrel in sandy ground in irrigated section near Bakersfield; excavated by J. Dixon and H. G. White, May 3, 1918.

Various entrances at *h*; food store at *a*; "back-door" exit for emergency purposes at *b*; nest cavities as indicated.

Total length, 138 feet; average diameter, 4¾ inches; greatest depth reached, 4 feet; volumetric content, 17⅝ cubic feet.

individuals at various times. These colonial burrows were not found to be in any case used as breeding burrows. It is possible that they may have consisted of one-time breeding burrows, now connected or linked together.

The relative extent of any one burrow system is thus dependent not only upon kind of ground—in other words, upon the difficulties encountered in digging—but also upon the estate of the individual or individuals directly concerned. Table I gives data in regard to the three types of burrows. In the seven burrows which were dug out and of which careful record was kept, the shortest occupied burrow was five feet long and the longest 138 feet. The average was 35.2 feet. The average diameter varied from 3½ to 5 inches, with a mean of 4.3 inches. The cubic air content was found to vary from 1.03 to 17.8 cubic feet, the average being 5.2 cubic feet.

TABLE I. *Data relative to burrows of the California Ground Squirrel.*

| Type of burrow | Locality | Date (1918) | Length of burrow (in feet) | Greatest depth of burrow (in inches) | Average diameter of burrow (in inches) | Cubic content of burrow (in cubic feet) |
|---|---|---|---|---|---|---|
| Male | Strawberry Canyon, Berkeley-- | April 3 | 5 | 18 | 3½ | 1.03 |
| Male | Strawberry Canyon, Berkeley-- | April 4 | 8 | 30 | 4 | 1.40 |
| Male | Strawberry Canyon, Berkeley-- | April 4 | 14 | 30 | 4½ | 2.40 |
| Male | 12 miles west of Fresno---------- | May 27-28 | 26 | 45 | 5 | 4.6 |
| Female | Strawberry Canyon, Berkeley-- | April 6 | 22 | 30 | 4½ | 4.8 |
| Male | San Emigdio Creek, Kern Co.-- | April 27-28 | 34 | 66 | 4½ | 4.8 |
| Colonial | 12 miles south, 5 miles west of Bakersfield ---------- | May 3 | 138 | 48 | 4¾ | 17.8 |
| | Average ---------- | ---------- | 35.2 | 38.1 | 4.3 | 5.2 |

In illustration of the fact of variability in depth and extent of burrow system with nature of soil, some actual instances as revealed by excavation may be described. The layers of alkali hardpan in the Fresno region were found to have a very decided influence on the course of the burrows. In most cases where the hardpan was near the surface, the burrows were found to extend through the hardpan to the soft ground that is often to be found just beneath. No evidence was found to indicate that the squirrel had dug through even thin layers of solid hardpan except at points where natural cracks or openings through it occurred. Slight cracks in the hardpan were sometimes enlarged, this apparently having been done during wet weather, to sufficient size to enable the squirrel, but not such an enemy of the squirrel as a coyote or badger, to readily pass through. In following the various cracks and openings through and between the strata of hardpan, the burrows were found to twist about in very erratic fashion. The sudden elevation in a burrow of sometimes as much as two feet was found to form a very effective barrier to the flow of any gas such as that of carbon bisulphid, which is heavier than air; such a gas would gather into the low places (see Stewart and Burd, 1918).

The deepest burrow system uncovered was situated in an alluvial talus in the foothills near San Emigdio, Kern County. The maintenance of the great depth (from four to five and a half feet for a distance of twenty feet) was clearly due to the squirrel having followed a soft layer at the margin of the talus down to below the level of the four-foot rock-filled surface layer. Beneath this the squirrel had progressed easily through the soft soil as long as he kept beneath the rocks—which he was practically forced to do (see fig. 6).

There seems to be little or no evidence to support the rather widespread notion that ground squirrels burrow down until they reach water. A colony burrow was unearthed in an irrigated section near Bakersfield, where the water level was known to be only five or six feet below the surface of the ground. No part of the burrow (see fig. 8) was found to extend deeper than four feet and hence not down to the water level. While ground squirrels do not absolutely require water, where surface water is to be had they often go considerable distances to secure it, going across the country sometimes as far as a quarter of a mile. In many places squirrels are found thriving where it is known that it is over 100 feet to ground water and miles to surface water.

It is quite likely that California Ground Squirrels construct new burrows from time to time, or, what is more probable, that each young individual as it approaches maturity leaves the parent burrow and digs a home for itself. In any event, in places there are many more burrows than individual squirrels present at any one time. Some of these tunnels, especially in the plains and foothill country, are joined together below ground to a greater or less degree and constitute the colonial burrows already described. When hurriedly seeking safety a squirrel will pitch down into the nearest one of a number of holes in the vicinity of the one about which it was first seen. The commonly uninhabited burrows may thus serve in extremity as temporary refuges.

The burrows of the squirrels are often inhabited by species of animals other than the rightful owners. Ground owls habitually make their homes in squirrel holes, probably deserted ones; and, to a less extent,

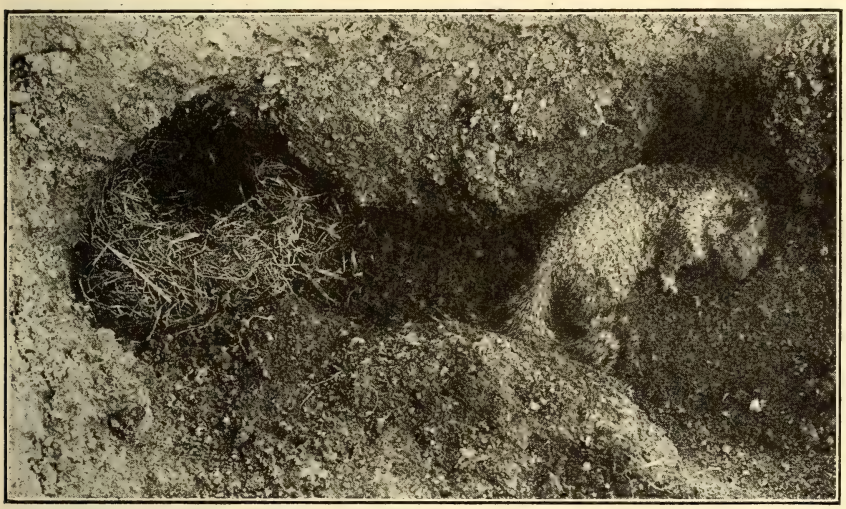

FIG. 9. Nest and male of "digger" squirrel as dug out after burrow was treated with carbon-bisulphid. The spherical shape of the nest-cavity and the structure of the nest itself is well shown.

the holes are frequented by California toads, Western gopher snakes and Pacific rattlesnakes. It is unlikely that the presence of the latter two animals is congenial to the squirrels, as both of these snakes are known to eat ground squirrels in numbers. Regularly communal occupants of squirrel burrows are scorpions, centipedes and mole crickets. Mole crickets were found to serve as reliable indicators of the efficiency of the gas when squirrels were fumigated in their burrows. If the gas had not killed the crickets it was found that the squirrels had not succumbed.

California Ground Squirrels are accustomed to furnish their underground quarters comfortably. Special nests are constructed and maintained in good order, where the individual may sleep or rest in warmth, free from contact with the damp earth. Each burrow occupied by a single squirrel was found to contain at least one well-made nest. In some cases there were two, one obviously older than the other. In the

colonial burrow that was dug out, three nests were found, of which two were new. The nests were always placed well back in the burrows (see figs. 6, 7), where they would have maximum protection from digging enemies such as coyotes and badgers. The cavities in which the nests were placed were short globular chambers and were usually situated slightly above and to one side of the main run, so that the drainage was away from rather than into the nest. The cavity in which a nest containing a female and four small young was found measured 10 inches in length, 9 inches wide and 7 inches high. The nest cavity used by a male squirrel was 12 x 10 x 7 inches (in the same dimensional order), while the two nest cavities in the colonial burrow measured 12 x 10 x 8 and 12 x 12 x 7 inches, respectively.

All of the nests found were of similar composition and construction. Finely shredded dry grass blades and roots, and fine stems of foxtail and needlegrass, formed the bulk of the constituent material. The nests were spherical in shape and deeply cupped. The walls were from

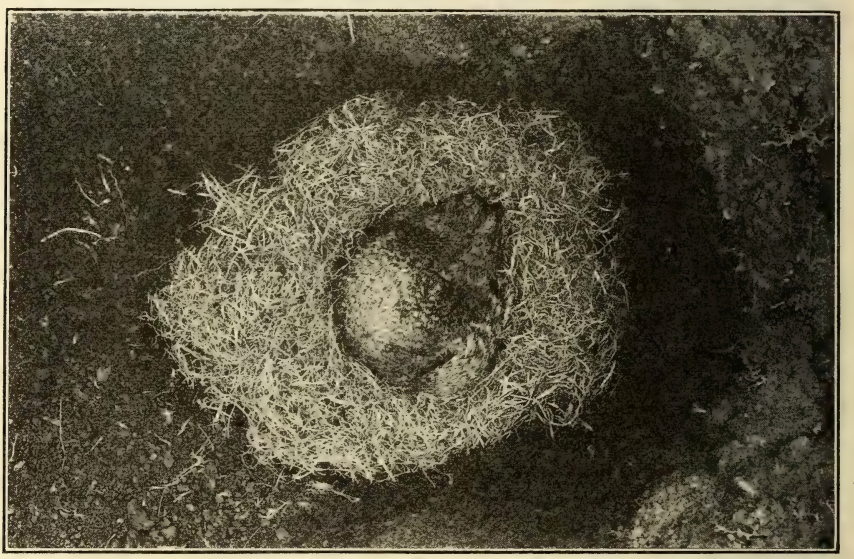

FIG. 10. Nest and female of "digger" squirrel as uncovered after the burrow had been gassed. Excavated on the University of California Campus, Berkeley, April 6, 1918.

two to two and one-half inches thick. The walls of the nest which contained the young squirrels were arched over and met at the top, forming a sort of a canopy. Entrance to this nest was gained through a hole near the top. The material in the walls had been compressed or felted into a thick, warm fabric. The outside dimensions of this nest were 10 x 9 x 7 inches, while the inside cavity measured 6 x 4 x 5 inches. Compared with that of the female just described, the nests of male squirrels were smaller, had lower walls and were more loosely constructed (see fig. 9). The nests of the males did not completely fill the cavities in which they were placed, as did the nest of the female. A nest occupied by a male measured 8 x 10 x 7 inches outside and 4 x 5 x 4 inches inside. The three nests in a colony burrow excavated

were large and evidently of considerable age, since the foxtail blades and stems composing the nests were old and broken up into short bits. One of these nests measured 12 x 10 x 8 inches outside and 6 x 5 x 4 inches inside, while the other measured 12 x 12 x 7 inches outside and 6 x 4 x 5 inches inside. The third nest was old, being merely a flat mat of trampled down bits of foxtail stems.

The nest of the female (fig. 10) was 30 inches below the surface of the ground. The nest of a male was 28 inches below the surface, while the two used nests in the colony burrow were 20 and 24 inches underground. The female and the male nests were in clay ground and the two colonial in sandy soil. The average depth of nests below the surface of the ground, taking into account all of the nests found, was 30 inches.

Contrary to general belief, we have found ground squirrels to be very cleanly animals about their nests and burrows. No feces (droppings or dung) were found in any nest. Such material was found

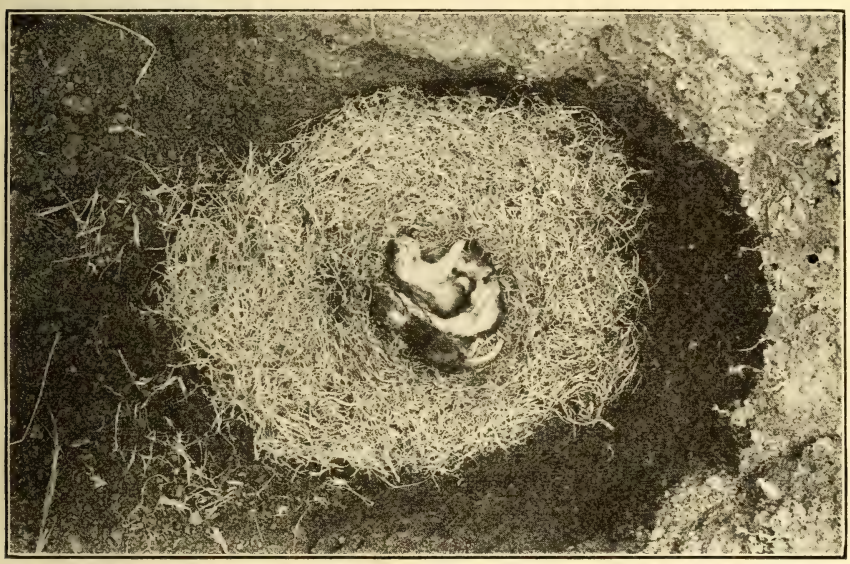

FIG. 11. Nest and small young of "digger" squirrel after removal of the female. Same nest as shown in Fig. 10.

heaped up in piles in special chambers usually just off the main run, but within easy reach, 18 to 24 inches, from the nest. These sumps were lower than the nests and were sometimes nothing but old nest cavities which had been dug somewhat deeper than they had formerly been. In the burrow of a male squirrel, a pile six inches in diameter and two inches high, of feces soggy with urine was found in a sump slightly below and fourteen inches distant from the nest. Female squirrels appear to be more particular in this regard than the males, in that the sump is farther removed from the nest.

The nest that contained the four young squirrels (see fig. 11) was alive with fleas, which swarmed over the helpless young. These fleas persisted in remaining in the nest for three days after the young

squirrels had been removed. Other nests were found to be infested with fleas, though at least one-half of the nests examined were free from these parasites. In certain localities squirrels were taken that were to casual appearance absolutely free from fleas, while in other localities squirrels taken were invariably infested to a greater or less extent. The species of flea that infests ground squirrels is not the species that commonly attacks human beings. While ground squirrels are their preferred hosts, we found that the former did not object to human society when their squirrel hosts had died. At least two methods are used by the squirrels to rid themselves of these uninvited guests. The first, or dust-bath method, is that of suffocation of the fleas which hide in their fur by thorough wallowing in especially dusty places. The second is by digging a new burrow and making a new nest, thereby leaving the bulk of the fleas behind.

Some years ago it was discovered that the fleas harbored by the California Ground Squirrel carried the bacillus of bubonic plague. A vigorous campaign of extermination was waged against the squirrels by the United States Public Health Service and they were practically eliminated from many areas, locally, in the San Francisco Bay region.

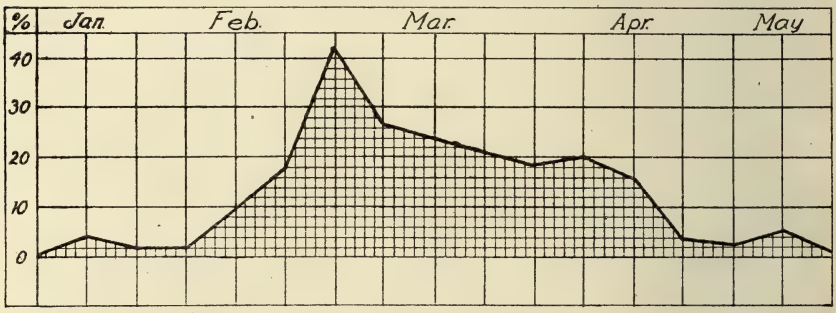


FIG. 12. Diagram showing extent and height of breeding season in the California Ground Squirrel. Heavy line shows percentage of females pregnant, for weekly periods from January to May. Based on record of embryos found in over 10,000 females examined by the United States Public Health Service (McCoy, 1912, p. 1070).

Soon after the efforts against the squirrels were relaxed the latter began to "spill in" from adjacent areas until now in places they are as numerous as ever. Nevertheless the prime object was attained, that of eliminating the foci of dissemination of the disease.

It is extremely important to know definitely the season and rate of breeding of any economically important rodent. Fortunately for our purpose, there is available for the California Ground Squirrel abundant data, supplied through the records of the United States Public Health Service (see McCoy, 1912, p. 1070). As will be seen from the accompanying diagram (fig. 12) based on over 10,000 females examined, the breeding season is restricted to a comparatively brief period of the year. Pregnant female ground squirrels have been taken in the Bay region as early as the first week in January, but the main breeding season does not begin until February, and it is practically concluded by the middle of April. The largest per cent of pregnant females is to be found during the last week in February. By June 4 only two-tenths of one per cent (0.2) of females examined contained embryos. At higher

altitudes, where warm weather comes on much later and more abruptly, these breeding dates would be correspondingly later and the breeding season still more restricted.

While males and females occur in practically equal numbers, mating seems to be promiscuous; there is no permanent pairing off.

The number of young per litter, as ascertained from counts of embryos, varies from 4 to 11. The average, from very extensive records kept by the United States Public Health Service (McCoy, 1912, p. 1070), may be inferred to be very close to 7.2. The same records serve further to show that there is some variation in size of litter from month to month. The average for February is 6.9; for March, 7.3; for April, 7.5; for May, 6.8. The tendency seems to be toward slightly larger litters in April, which is beyond the date of maximum number of pregnant females (see fig. 12). Number of mammæ (nipples), which is usually six pairs in this species, occasionally but five, is no criterion for number of young per litter. All the evidence at hand indicates that each female raises but one litter each year. A female ground squirrel was taken on the University campus at Berkeley, on March 13, 1918, which contained eleven embryos each of which measured three-fourths of an inch long. Eight of these were contained in one branch of the uterus and three in the other. Another female taken at the same time contained eight embryos, each of which measured five-eighths of an inch long. Five of these were in one branch of the uterus and three in the other.

On April 6, 1918, G. R. Stewart and the junior author dug out two female ground squirrels which had been previously gassed in their burrows. One of these females was found in a nest with four small young which we took to be about ten days old, since their eyes were not yet open. These baby squirrels averaged 170 millimeters or $6\frac{3}{4}$ inches in length; a typical one weighed 61 grams, or a little over 2 ounces. They were well covered with hair, which already showed on the back the characteristic dappled pattern of the adult squirrel. The tail, however, was nearly round and showed little sign of the fringe of hairs along the sides. Their stomach contents showed no sign of their having eaten green vegetation or anything else than milk. Data from other sources indicate that the young are not completely weaned until they are at least half grown. The other female secured in an adjoining burrow not over ten feet distant was found to contain seven small embryos each of which measured three-eighths of an inch in length. These embryos could not well have reached full development short of two or three weeks, so we have a variation of nearly a month in time of birth at one locality.

Cases such as those just given are thought to be exceptional and may serve in part to explain the occurrence of late litters such as have been the basis of the claim that this animal has two litters a season. Litters of young squirrels which sometimes appear very late in the season are, too, likely to be merely the result of efforts to replace first litters of young which have met an untimely death. Thus two litters might be born in one season, though only one *raised*.

Shaw (1916, p. 4) gives 24 or 25 days as the period of gestation in the Columbian Ground Squirrel (*Citellus columbianus*) in the region about Pullman, Washington. The period of gestation of the California

Ground Squirrel has not to our knowledge been determined; yet the facts at hand, such as the general rate of development of the embryos, and of the young after birth, lead us to believe that it is close to thirty days.

The bulk of the young ground squirrels in any one locality make their appearance with remarkable uniformity as to size and regularity as to date. Our data is incomplete, as to exact time of birth; but we have plenty of records of embryos in various stages of development, and we can observe the time of appearance of the young squirrels above ground. In the lowlands the majority are probably born the last of March, and by the last of April the first born are beginning to appear aboveground, playing about the mouths of the burrows. In the higher altitudes the young are born later. Females in the Transition Zone and lower part of the Canadian Zone had not yet given birth to their young in June. "Spring" in the lowlands comes in April, while the spring of the higher altitudes does not occur until late June or July. Hence the young *do* appear at the same *season*, considering the differences in temperature conditions at the different elevations. The accumulation of a certain quantity of heat from without seems to be necessary each year to start the squirrels breeding.

Young California Ground Squirrels may be considered fairly precocious. They ordinarily begin to venture outside their nest burrows when yet very small, in ascertained cases only one-fourth or even one-fifth the weight of the adults. They are then probably not over four weeks old. At Snelling, Merced County, on May 28, 1915, C. L. Camp (MS) observed that young "evidently just emerging for the first time in their lives, seemed confused when they saw a horse and buggy and often ran almost directly under the wheels." Two months later, in the high mountains, the young squirrels behaved the same way. A probably abnormal occurrence was that of a very young squirrel found on April 29 wandering aimlessly about in the grass near a burrow entrance. This squirrel weighed only 61.5 grams, or less than one-tenth the weight of adults. It was practically helpless and would have fallen easy prey to any sort of predaceous animal.

The first litter of young ground squirrels seen aboveground in the season of 1918 by the junior author was noted on April 28 at 1,500 feet altitude on San Emigdio Creek, Kern County. In this litter there were six young at least one-third grown. Judging from the "sign" about the burrow, these youngsters had been foraging above ground for a week or ten days. The season at this altitude was at least ten days later than it was down on the lower parts of the San Joaquin Valley. Several burrows of small diameter and amateurish construction were found at the edge of a thick patch of alfilaria that grew near the nest burrow. These young squirrels in spite of their small size were busily harvesting the heads of the ripening alfilaria and when alarmed ran down the small burrows which each had dug for himself. While the observer was standing over one of these burrows a youngster came up halfway out of a hole six feet away, but catching sight of him gave a hasty alarm note and scurried back down the hole. Twenty-five minutes elapsed after this before any of the young squirrels reappeared above ground.

As far as is to be observed, the male takes no active interest in the welfare of the young. Indeed, he dwells altogether separately from the family and does not see his offspring until they begin foraging out of doors. His only function at all, as regards the upbringing of the young, is that of sounding general alarm throughout the colony when danger threatens. As for the mother, even she is notably indifferent to her young after they appear above ground. When suddenly alarmed, she flees to safety on her own account, leaving the youngsters to shift each for himself as best he may.

The rate of growth of the young is such that they reach mature size by September, when they are from four to six months old (McCoy, 1912, p. 1069). But before this time, by the first of August, the young of the year begin to emigrate locally, so as to establish each for himself a new home. It is likely that this process of emigration is hastened by the development on the part of the parents of an attitude of incompatibility. According to this idea the initial solicitude of the mother for her young at the helpless age is later reversed, so that she becomes antagonistic to them and finally speeds their departure. The young, at the same time, begin to give evidence of an instinct to wander. At any rate, the month of August sees the important phenomenon of emigration or dispersion well under way. Young of the year then put in their appearance in unexpected places; new ground is invaded, and the total territory occupied by the squirrels increased in extent insofar as the increase in population makes necessary and the favorable nature of the country permits. Undue congestion of population tends thereby to be prevented.

The natural enemies of the California Ground Squirrel are of many kinds, and under original conditions so many as regards individuals as to provide a regular automatic check to any abnormal increase of the squirrel. The most important are golden eagles, red-tailed hawks, coyotes, badgers, wildcats, weasels, rattlesnakes and gopher snakes. Each of these various animals pursues the squirrels in its own particular way. Hawks and eagles swoop down on them from their vantage points in the air. Wildcats and coyotes lie in wait near the burrows until the squirrels venture forth in search of food, when they pounce upon them. Badgers, weasels and snakes capture the squirrels in their burrows. Some specific cases will be cited here. It must be remembered that, while casualties to squirrels may be inflicted by their customary enemies almost hourly in any general neighborhood where man has not exterminated these predators, the chances of a person's being in a position at the critical moment to witness a tragedy of this sort are rare. At the San Emigdio Ranch in Kern County on April 25, 1918, the junior author watched a Golden Eagle (*Aquila chrysaetos*) capture and devour an adult ground squirrel. The eagle was first observed flying quietly down a canyon. By weaving in and out in its course the bird was able to skirt the irregular hillside so as to keep within fifteen or twenty feet of the ground. At length the eagle skimmed abruptly around the shoulder of a hill, just clearing the tops of the wild oats, and dropped quickly down upon a luckless ground squirrel. The latter had evidently been on a foraging expedition and did not have time to reach his burrow, so complete was the surprise. The eagle seized the squirrel with both sets of talons, and the piercing grip by these effective

instruments quickly dispatched it. The bird then proceeded to tear the animal to pieces with the stout beak and, perched on the ground, devoured it on the spot. The strategy and success of this method of attack was obviously dependent upon the eagle keeping close to the ground so as to remain out of the squirrel's range of vision until the last moment.

At Pleasant Valley, Mariposa County, on May 17, 1915, C. L. Camp (MS) fed a ground squirrel that had been shot, to a Golden Eagle kept captive by a storekeeper there. The eagle ate head, skin and bones, but discarded the stomach and large intestines. Other birds, such as the turkey vulture, have been observed by the junior author to similarly avoid the stomach and intestines of ground squirrels that have been killed by taking poisoned barley. Coyotes have also been known to show the same fine discrimination when eating ground squirrels which they themselves have not caught.

Some idea of the success with which Golden Eagles sometimes pursue ground squirrels may be had from the fact that at Lilac, San Diego County, on April 4, 1907, James B. Dixon (MS) found eleven freshly caught ground squirrels in and about an eagle's nest that contained two eaglets about a week old.

During the spring of 1904 W. L. Finley and H. T. Bohlman observed and photographed a pair of young Golden Eagles in various stages of development from the time the eaglets were nine days old until they left their birthplace nearly three months later. The aerie was a bulky affair placed in a horizontal fork of the upper limbs of a large sycamore tree that grew in a canyon back of Mission San Jose, Alameda County. In speaking of the food of the Golden Eagle, Finley (1906, pp. 9-10) says: "His food consists almost entirely of the ground squirrels that are so abundant through the California hills. On our second trip [on April 12], when we looked into the nest, we found the remains of the bodies of four squirrels lying on its rim. At each visit we examined the food remains and the pellets about the nest, and we are sure that a very large proportion of the eagles' food supply consisted of squirrels. . . . I am satisfied that this family of eagles regularly consumed an average of six ground squirrels a day during the period of nesting, and, very likely, more than that. . . . But even this low estimate would mean the destruction of 540 squirrels along the hillsides in about three months' time."

The nest of a Western Red-tailed Hawk (*Buteo borealis calurus*) examined by J. B. Dixon (J. Dixon, 1917, p. 12) on March 28, 1906, and containing one day-old chick, two pipped eggs and a rotten egg, was found to contain also the remains of two ground squirrels. This was near Vista, San Diego County. At Pala, in the same county, the same observer found the nest of a Red-bellied Hawk (*Buteo lineatus elegans*), April 3, 1916, containing three young, a week old, together with one ground squirrel and two pocket gophers. The dead squirrels counted in the nests represent, of course, merely the surplus which the old birds had just carried to the young. The squirrels that the old birds themselves or the young may have eaten on the day of observation are not taken into account.

At Dunlap, Fresno County, on September 30, 1916, H. S. Swarth (MS) found a large rattlesnake (*Crotalus oreganus*) which showed a

bulge in the middle portion of its body. This proved to mark the location of a full-grown ground squirrel, which had been swallowed entire, head first.

Near the mouth of Tejon Creek, Kern County, on July 16, 1914, C. L. Camp (MS) watched a rattlesnake (*Crotalus oreganus*) about three feet and a half long, swallow a ground squirrel. He describes the incident essentially as follows: The snake had just bitten the squirrel on the side of the face below the eye. The squirrel flopped about for five or ten minutes and then dropped over a bank and died, out of sight of the snake. The snake then slowly crawled down over the bank after its prey, found it, touched it all over with the end of its tongue, and then seized the animal by the nose. The squirrel moved slightly. The snake drew back and waited motionless for some time. The snake then got a fresh hold on the squirrel's nose, pulled the body out straight, and started to work its jaws over the squirrel's head. Things went rapidly as far as the squirrel's ears, then operations proceeded more slowly. The snake writhed about and gradually worked its jaws over the shoulders of the squirrel, first moving the upper jaw forward with slight jerks and then pulling up on the lower jaw. Finally, after the rodent had been half swallowed, we approached closer to take a picture and the snake disgorged the squirrel as the result of a violent effort lasting a minute or so. We went away and in a little while the snake returned to its food and had swallowed it almost completely within 15 or 20 minutes more.

On Pine Flats, in the San Gabriel Mountains, a large, lazy rattler was secured which showed a bulge about halfway along its body. Dissection disclosed a full-grown California Ground Squirrel which had been swallowed. (Grinnell, J. and H. W., 1907, p. 53.)

On San Emigdio Creek, Kern County, on the morning of April 23, 1918, the attention of J. Dixon (MS) was attracted by the nervous barking and peculiar actions of a large male ground squirrel. With the aid of the binoculars, the actions of the squirrel, which was less than 75 yards distant, were easily followed. The squirrel was obviously much wrought up and his sharp, nervous notes were quite different in pitch and intensity from the ordinary metallic alarm note. The animal's attention was continually focused upon an opening just beneath a certain small white rock at the edge of a stone pile. While his attention thus remained fixed, the squirrel kept running back and forth in a semicircle about thirty inches distant from the object concerned. During this time the squirrel's tail, which was held arched over his back, was twitched violently sideways every time he barked. The alarm notes were uttered during a momentary pause at the end of each advance in the arc-shaped path of the squirrel. The squirrel's whole demeanor reminded the observer of that of a pup that has cornered some old pussy cat and still hesitates to make an attack. Having witnessed three similar performances by ground squirrels, in San Diego County, the observer proceeded to investigate and found, as in the three previous instances, that a coiled rattlesnake was the cause of the excitement. In the present case there were two, a male and female, tightly coiled together at the mouth of a squirrel burrow, and they were dispatched. An hour later this same squirrel, which was easily identified by a peculiarity in its pelage due to wear, was observed digging a new

burrow some fifty feet distant from where the rattlesnakes had been. There was no way of determining whether the presence of the snakes had influenced this action, but it was evident that this squirrel made no effort to fill up the entrance to the burrow which had been preempted by the snakes. It is a popular notion that ground squirrels, when the opportunity offers, bury snakes alive.

As for mammals as enemies of ground squirrels, the evidence most readily obtainable is derived from examination of the excrement of the former. Coyotes have regular places for deposit of excrement, on hill tops or ridges. Bones and teeth of ground squirrels frequently have been found represented in these deposits (J. Grinnell, MS). The remains of two freshly eaten ground squirrels were found in the stomach of a wildcat killed in central San Diego County (J. Dixon, MS).

As to food, the California Ground Squirrel shows a wide range of taste, even though there are at the same time decided preferences. He cheerfully adopts substitutes when favorite foods are lacking; he is not averse to taking considerable barley with his wheat. A list of all the plants eaten by the ground squirrel would be a very long one, and if locality be taken into account great variation would doubtless be found from place to place. The above general statements will be borne out, in part at least, by the data presented in the paragraphs to follow.

On the University campus at Berkeley, on March 13, 1918, the majority of the California Ground Squirrels were feeding on the tender leaves of alfilaria (*Erodium*). A female squirrel was observed by the junior author at this time to eat the leaves of young plants of the star thistle (*Centaurea*). On San Emigdio Creek, Kern County, on April 28, 1918, a squirrel was seen to disappear down a hole carrying a sheaf of freshly cut heads of foxtail (*Hordeum*) held tightly in his mouth. A few minutes later this squirrel was gassed and when the burrow was dug out the fresh foxtail heads were found on the edge of the nest. Previously this squirrel was seen to gather heads of both foxtail and alfilaria, but preference was given to the latter (J. Dixon, MS). The young as well as the old squirrels seem to prefer alfilaria when obtainable to any other plant.

In the region about Walnut Creek, Contra Costa County, on July 26 and August 16, 1918, the authors found ground squirrels feeding extensively on seeds of bur clover (*Medicago hispida*). Dried burs of this plant were abundant on the hillsides in the near vicinity of the squirrel burrows, and although there was a plentiful supply of barley on the adjacent stubble fields this was in major part passed up in favor of the clover seeds. Hulled seeds of the bur clover were found to predominate in the cheek pouches and the stomachs of the score or more squirrels that were shot. This fondness on the part of the ground squirrels for bur-clover seed suggests a possibly better way of poisoning these rodents by using the entire bur of the clover than by the use of barley, wheat or other grains, which are now so badly needed for human consumption.

In southern California the seeds of the plant known as wild cucumber, manroot, or chilicothe (*Echinocystis macrocarpa*) is eagerly sought by ground squirrels. Gnawed hulls of the seeds of this plant are frequently found in large quantities near the summits of rock piles where the husking or lookout stations of the squirrels are located. In Yosemite

Valley a ground squirrel was seen gathering green fruits from the top of a four-foot manzanita bush.

C. H. Merriam reports (1910, p. 5) that the seeds of the manroot (*Echinocystis fabacea*) are eaten in the vicinity of Modesto from the middle of May to the middle of December. The seeds are eaten from

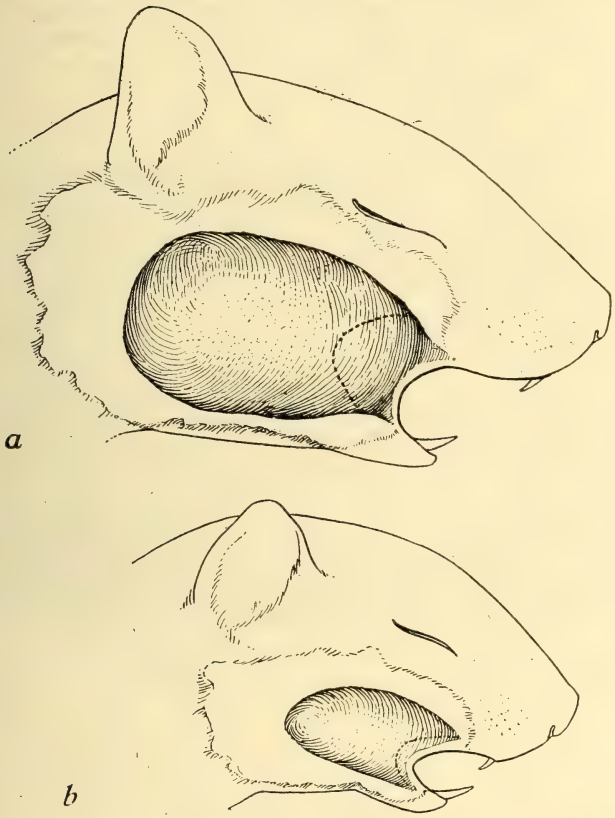


FIG. 13. Drawings from dissections to show relative extent of cheek-pouches in (a) California Ground Squirrel and (b) Belding Ground Squirrel. One cheek-pouch opens into the mouth cavity on each side; it is lined with membrane continuous with that lining the mouth and is used for carrying food materials such as seeds and bulbs from the forage ground to either the store house or the husking place. It is to be inferred that the California Ground Squirrel is much more of a seed-gatherer than the Belding. The latter, like the Oregon Ground Squirrel, is more of a grass-eater, and also does not garner food to the extent that the "digger" squirrels do.

the time they begin to form until they are fully ripe. "Other favorite seeds are those of elderberry (*Sambucus*), jimson weed (*Datura*), wild nightshade (*Solanum*), turkey mullein (*Eremocarpus*), tarweed (*Madia*), and numerous grasses. . . . In southern California the squirrels are fond of the fruit of the prickly pear (*Opuntia*)."

Ground squirrels are provided with more or less extensive, membrane-lined cheek pouches opening inside the mouth, which are used in gathering and transporting food (see fig. 13). Often when the animals are scared out of weed patches or bushes, or away from some supply of roots



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or bulbs which they have discovered, their cheeks are seen to be bulging with the contents of these pouches. They are able to operate their teeth and lips even when these pouches are copiously distended. The cheek pouches of the California Ground Squirrel are especially well developed and this, we think, is correlated with the pronounced seed gathering and storing propensities of this species. The following records of cheek-pouch contents, as secured from specimens collected, contribute further to our knowledge of the kinds of food of this animal and also of the quantity in which these may be gathered.

A female taken in a stubble field near Walnut Creek, Contra Costa County, July 26, 1918, held in her cheek pouches 26 seeds of bur clover. A male taken August 15, 1918, at the same place had 78 seeds of bur clover and one seed of needle grass. Two other males had one and three bur-clover seeds, respectively. Another female taken at the same time and place contained 212 seeds of bur clover and 12 seeds of some kind of wild grass. Another male held 97 grains of barley and three bur-clover seeds. A ground squirrel taken at Cisco, Placer County, on October 9, 1913, was carrying 92 seeds of the green manzanita (*Arctostaphylos patula*), while a squirrel secured near Pleasant Valley, Mariposa County, on May 28, 1915, had dug up and was carrying in its pouches 12 bulbs of a species of wild hyacinth (*Brodiæa hyacinthina*). At El Portal, Mariposa County, a squirrel was secured with three large acorns of the golden oak in its cheek pouches.

We will now consider those feeding habits which make the California Ground Squirrel come into conflict more directly with man's interests. "Of cultivated nuts, almonds and walnuts are preferred; of other crops, apples, prunes, peaches, apricots, figs, olives, . . . the seeds of cantaloupes, watermelons and citron melons, and all the grains are eaten whenever they are to be had, and green alfalfa and clover are sometimes taken" (Merriam, 1910, p. 5). Frank Stephens (1906, p. 66) has summed up the food taken by this animal as follows: "The food is principally of a vegetable nature, preferably grain and other seeds, fruit, potatoes, green plants, etc. Eggs of poultry and wild birds are relished." We have heard considerable testimony from ranchers to the effect that individual ground squirrels in different localities have learned to raid henneries, so that the above statement is not exceptional.

A great deal of damage is done by California Ground Squirrels each year in orchards and vineyards. The following instances, given by Merriam (1910, p. 6) are typical of such depredations. "Ground squirrels are particularly fond of green almonds and of the pits of green peaches and apricots, eating these from the time the kernels begin to form until the fruit is ripe, thus doing serious damage. They are very destructive to apples also, and in places in the foothills of the Colfax-Auburn region are said to take fully half the crop. . . . In the fall of 1907 E. A. Goldman reported that they were doing serious damage to young vineyards about Orosi, in Tulare County, by biting off the leaves and tender shoots of the vines. . . . In the orange groves between Porterville and Springville, in Tulare County, it is reported that they occasionally gnaw the bark of the orange trees and sometimes cut the fruit and carry it off. Besides destroying nuts and fresh fruits they attack drying prunes and carry off large quantities."

On May 14, 1918, near the mouth of Caliente Creek wash, Kern County, in one corner of a 640-acre field planted to wheat, four large bare spots were counted by the junior author in an area of not over ten acres. These denuded areas were circular in shape and averaged 75 yards in diameter. They were caused by the ground squirrels having eaten and destroyed the ripening wheat and even the stalks so that nothing but weeds remained. In a single one of these denuded areas twenty-three occupied squirrel burrows were counted. In this same field, within a six-foot circle the center of which was a lone squirrel burrow, 113 heads of wheat were picked up (see fig. 14). These heads

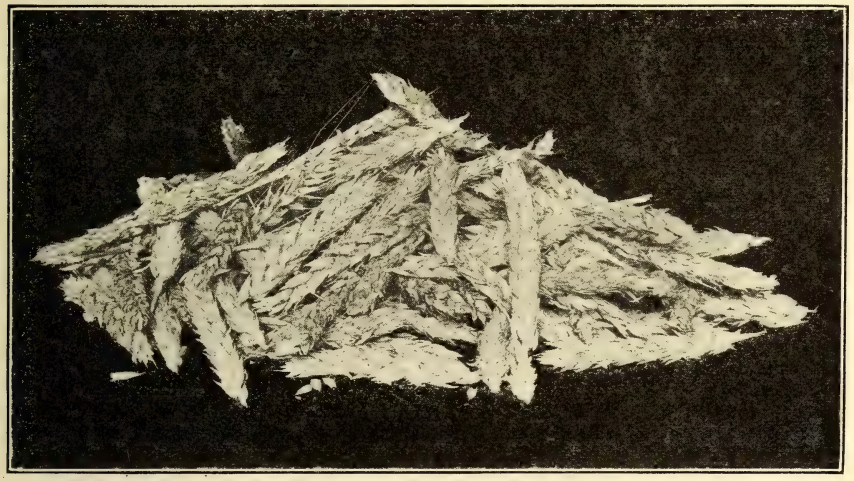

FIG. 14. These 113 heads of wheat were picked up within a six-foot circle, the center of which was a "digger" squirrel burrow situated in the edge of a wheat field. They were part of what had been gathered within three or four days, apparently by the one squirrel.

had all been cut and carried to the burrow within three or four days, as they were not yet dry. This was evidently the work of a single squirrel, since no other squirrel was seen to go near the burrow. These 113 heads of wheat probably constituted part of what was intended for storing, and did not include that required for current consumption.

In gathering food California Ground Squirrels slink along slowly close to the ground, often half hidden in the grass. In gathering ripe alfilaria only the clusters of seed cases are taken, with relatively little of the stem. However, when the plants are young, the stems and leaves are much relished by the squirrels. The usual method of feeding as revealed by the binoculars, is for the squirrel to sit up on his haunches within reach of the alfilaria heads, which are dexterously gathered into little bunches by the front paws of the animal and then quickly snipped off by the sharp incisor teeth. During this last operation the head of the rodent is often inclined to one side. In gathering bulky food materials such as the heads of foxtail the cheek-pouches are not always used, the material being carried crosswise in the squirrel's mouth directly to the burrow.

On the San Joaquin River near Mendota R. M. Hunt (MS) reports seeing squirrels go out into the tules of the sloughs seemingly to eat the

green stalks. Several times on following up rustling sounds squirrels were discovered on thick mats of dry fallen tules among the standing green ones and just above the water. One, on being alarmed, jumped into the water with a splash and, although lost to sight, probably reached safety by swimming. Davis "Island," near Mendota, is part of the mainland at low water, but in May, with high water, becomes a true island and with the highest water the ground everywhere is completely submerged. On June 20, 1918, a squirrel was discovered on this island. It jumped from a piece of ground into the water and *swam,* in much the manner of a dog, to a tree up which it took refuge.

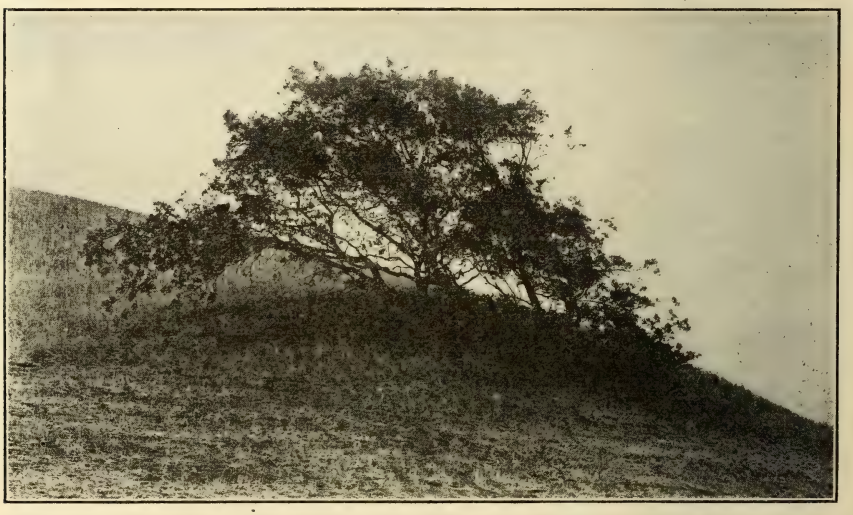

FIG. 15. Metropolis of "digger" squirrels under a small oak on a grain-sown hillside; photographed near Walnut Creek, Contra Costa County, August 15, 1918. Owing to the dryness of the season and to the depredations of the squirrels, the grain on the hill above the oak had been left uncut.

A current report was to the effect that each year at high water ground squirrels are marooned on this island and live for the time being in the big hollow-trunked willows there. This shows that flooding does not necessarily drive out or drown these squirrels in such localities as afford refuges on high ground or in trees.

On wild land, alfilaria, foxtail and bur clover are perhaps the three plants that are eaten to a greater extent than any other of our forage plants. Alfilaria is eaten from the time it appears above ground until it ripens, and even after that, when the seeds have scattered out, they are gathered and either eaten at once, or stored. The long, curled "propellers" are broken off and discarded. In Strawberry Canyon on the University campus, in April, the squirrels were harvesting foxtail and alfilaria on sunny southern exposures where the plants had matured early. Later in the season, during late June and early July, these same squirrels with their families of half-grown young were found to have moved down the hillsides, some 150 yards, to the moister, shady ground near the creek bed where the foxtail was still green, and here they were busily gathering the foxtail heads just ripening on July 6. There is an obvious rotation in the use of the different important plants for food,

dependent upon the sequence in which they become available. Thus, alfilaria is eaten during winter and early spring; then the foxtail crop claims attention; and the bur clover, after its seeds ripen, is harvested all through midsummer and autumn. Of course the above statements are only of local application.

Examination of the food stores of ground squirrels would go far toward providing adequate knowledge of their food habits. Such investigations should be made preferably in the fall. Specific information now available is as follows:

In digging out a colonial burrow near Bakersfield, Kern County, on May 3, 1918, a storehouse was uncovered. This consisted of a cavity or pocket off the main run (see *a*, fig. 8), which measured five and a half by eight inches in two diameters and was eighteen inches beneath the surface of the ground. The stored food consisted of a double handful of nearly dry heads of foxtail grass carefully packed in dry sand. A few alfilaria seeds were also included with the foxtail, but alfilaria was scarce at this locality.

Upward of fifty of the button-like seeds or "cheeses" of the mallow (*Malva*) were observed at the entrance of another burrow at the same place, but the observer was unable to determine whether or not these seeds were being stored. The mallow seeds were found for the most part on the lookout station at the entrance to the burrow.

"At Modesto in May, 1909, Piper found stores of alfilaria seeds packed in cavities and well mixed with dry sand. In December of the same year he examined a number of stores of grain unearthed by a farmer while scraping and leveling his land. Each of these caches consisted of from a pint to a quart of oats stored in cavities and packed in dry sand. They varied from 8 to 18 inches in depth beneath the surface; some were in short blind holes; others at the ends of branches of the main burrow" (Merriam, 1910, p. 5).

An idea of the quantity of food eaten by the California Ground Squirrel can be derived from the following data:

A female taken near Coulterville, Mariposa County, on June 3, 1915, weighed 553.5 grams, or about a pound and a quarter. The stomach and its contents alone weighed 77.5 grams, or about $2\frac{3}{4}$ ounces (C. L. Camp, MS). Figuring out the ascertained weight of the stomach in other individuals, 5 grams, the ratio of stomach contents to total weight in this squirrel proves to have been about 1 to 7. The material represented is presumed to have been fresh green stuff.

Some experiments have been carried on at the Museum with captive squirrels with the purpose of determining the amount of green forage consumed daily. Fifty grams, or nearly two ounces, of green alfilaria was found to be the average daily ration for an average-sized squirrel. In cases where all food had been withheld from the squirrels the previous day, the greatest amount of succulent alfilaria, the favorite food of the squirrel, consumed in one day was 80 grams, or somewhat less than three ounces.

Five immature ground squirrels taken July 26, 1918, near Walnut Creek, Contra Costa County, gave an average total weight of 504.3 (427.2–517.2) each in grams. The average weight of the stomach contents in these five squirrels was 13.2 (10.3–19.0), so that the average ratio of the weight of the stomach contents to the total weight was

1 to 38 (1 to 50–1 to 22). The stomach contents in these cases consisted almost entirely of finely chewed seeds of barley and bur clover. The squirrels were shot between noon and 2 p.m. Seven full-grown males taken on August 15, 1918, near Walnut Creek, gave an average total weight of 659.4 (576.8–724.7) grams each; the average weight of the stomach contents was 17.9 (11.5–20.5); and the average ratio of contents of stomach to total weight was 1 to 37 (1 to 63–1 to 30). Seven full-grown females taken at the same time and place gave an average total weight in grams of 500 (370.7–681.4) each; the average weight of the stomach contents was 9.7 (5–15.8); and the average ratio of contents of stomach to total weight was 1 to 42 (1 to 101–1 to 37). All these fourteen squirrels were foraging in stubble fields, and the stomach contents consisted of barley and bur clover seeds finely chewed and of nearly the same degree of moistness as ordinary baker's dough. The squirrels were shot between 10 a.m. and noon.

It is believed by us that two ounces of green forage or one-half ounce of dry grain is an average stomach-full for an average-sized California Ground Squirrel and that two stomach-fulls represent a day's ration. It is evident that the proportion between the weight of the stomach contents and the total weight averages considerably less in this species than it does in the Oregon Ground Squirrel. The California is more of a seed eater and less of a grass eater than the Oregon Squirrel and therefore enjoys a more condensed ration.

During late summer digger squirrels, particularly the old adults, become exceedingly fat. In this condition they become obviously lazy and may often be seen lounging at the entrances to their burrows simply enjoying the sunshine. As the season farther advances, a decided decrease in squirrel population is noted. The active young of the year are still foraging abroad, but even these restrict their activities to the brightest hours of sunshiny days. What becomes of the squirrels which have altogether disappeared underground?

One would naturally expect that the life history of such a notorious animal as the California Ground Squirrel would be known pretty thoroughly. However, such does not seem to be the case; there are several features of the underground life of this squirrel in regard to which our information is very inadequate and of which from the standpoint of rodent control it would be most useful to know. As has been previously mentioned, little appears to be definitely known regarding the period of gestation of this animal. The condition of the young at birth and their subsequent care and development is also not well known. Another moot point is that of æstivation or hibernation of this species of ground squirrel. Merriam (1910, p. 4) states that "this species does not hibernate, except in the mountains, although in the foothills and valleys the animals usually stay in their burrows during stormy and severe weather. At the upper limit of their range, where the ground in winter is covered with snow, they may remain underground long enough to be said to hibernate, but over the greater part of the state they are out in numbers every month of the year." However, we believe we have evidence to indicate that a period of æstivation or hibernation (or the two combined), in other words a state of torpidity initially induced by the heat and dryness of summer, obtains among some at least of the adult ground squirrels even in the lowlands. This

period of dormancy extends from late summer well through midwinter, and thus "æstivation" may be said to go over directly into true hibernation. The old adults seem to be the only ones that "hole up," for the young adults somewhat less than a year old, that is, the young of the year, may be seen about the burrows during suitable weather throughout the winter.

In support of the above belief, that a period of torpidity overtakes the older individuals of the squirrel population regularly each year, the following evidence is submitted:

(1) Close watch, extending over a period of between four and five years, was kept on a female ground squirrel that lived in the dooryard at the home of Mrs. Elizabeth Grinnell in Pasadena. This particular squirrel did not æstivate until its second year. Then and during each succeeding year of its life it æstivated regularly, becoming very fat and retiring to its burrow during the last week in August. It emerged lean and hungry, with marked regularity, about the twenty-second of each following February. When removed from the burrow at intervals during this period, the squirrel was found to be in a torpid state, with respiration not perceptible.

(2) In a case in the junior author's personal experience, near Escondido, San Diego County, all the squirrels that were active in a certain field in the fall were poisoned or otherwise killed, and yet old breeding squirrels suddenly appeared in this same field the following February. This occurred when there was seemingly no possible chance for reinfestation from the surrounding fields, which had been cleaned up also. Similar testimony has reached us from a number of men identified with efforts to exterminate these rodents.

(3) It occurred to the present writers that it might be possible through the examination of specimens to learn the extent to which old adults are out in midwinter. The heads of 186 ground squirrels were, at our request, secured by the United States Public Health Service, shot and trapped near Martinez, Contra Costa County, during January, 1918, and sent to the Museum of Vertebrate Zoology, where the skulls were cleaned and carefully examined. Relatively advanced age was determined from the skulls upon the following criteria: general size, zygomatic breadth, breadth of jugals, stoutness of postorbital processes, degree of development of sagittal crest, degree of approach of parietal ridges, breadth and degree of concavity of frontal surface, advance in coalescence of the adjacent bones along certain sutures, and amount of wear on the crowns of the molariform teeth.

The results of our examination are given in Table II:

TABLE II. *Proportions of adult to young ground squirrels abroad in midwinter.*

| Date received (in 1918) | Total number of skulls | Number of old adults | Number of young adults | Ratio of old adults to total |
|---|---|---|---|---|
| January 8 | 18 | 1 | 17 | 1 to 18 |
| January 14 | 34 | 4 | 30 | 1 to 8.5 |
| January 22 | 86 | 18 | 68 | 1 to 4.7 |
| January 24 | 48 | 11 | 37 | 1 to 4.3 |

The foregoing data are not nearly as complete as could well be desired, but as far as they go they show that "old adult" squirrels are relatively

scarce aboveground in January as compared with the younger animals, those probably less than one year old. Further, the proportions of old to young increases rapidly towards the last of that month; in other words, as the breeding season approaches. It is probable that the full old-adult population is not abroad aboveground until the last of February, when the ratio of old adults to young of the previous year would certainly not be nearly so little as 1 to 4, which is the minimum possible at the immediate close of the breeding season.

In spite of the above lines of evidence, the real extent of this habit of æstivation among our ground squirrels is not satisfactorily known. It is exceedingly difficult to follow any individual squirrel under perfectly normal conditions through all its various activities for any great length of time. However, an important factor concerned in the work of destroying these animals is suggested; that is, the desirability of placing emphasis upon the need of poisoning in the spring rather than in the fall, when part of the breeding stock may be stowed away out of the reach of poisoned grain. It is a question, too, whether or not a dormant animal, in which respiration is extremely slow, would be fatally injured by a fumigant before the latter would be dissipated.

Human interest in the California Ground Squirrel naturally concerns itself most especially with the questions of total population, rate of increase, and rate of re-invasion of territory previously cleaned of squirrels. As to the first question, we have found it difficult to find an accurate basis for determining the squirrel population living on any given unit of area, such as an acre or a square mile. Counts may be taken of living squirrels that happen to be aboveground at any one time, or of burrows which give evidence of current use. In the first case the count is never likely to cover all of the squirrels in the area, because the chances are overwhelmingly against all of the squirrels being aboveground at one time. Season of the year, time of day, and state of weather will affect profoundly this proportion of squirrels below ground to those in sight. In the latter case some sort of estimate of ratio of squirrels to burrows must have been arrived at. Season of the year must again figure importantly in the estimate, because of the jump in population following the breeding season, and progressive decrease thereafter.

On July 26, 1918, the authors took two censuses of ground squirrels on a badly infested ranch about three miles northwest of Walnut Creek, Contra Costa County (see fig. 16). The first census was taken on a south-facing hillside on an area 100 feet square, approximately one-fourth of an acre. Three counts gave 19, 16 and 17 squirrels, respectively, in sight at once. Twenty-five open burrows were counted in this area. This, therefore, was at the rate of 76 squirrels and 100 burrows per acre, or $1\frac{1}{3}$ burrows to each squirrel. The breeding season at that date was well passed. Allowing one adult to every four young gave fifteen adults to every 100 burrows or between six and seven open burrows to each adult squirrel after the breeding season.

The second census was taken in a mowed field from which a crop of barley hay had been recently harvested. The area taken was on a north slope and measured 250 feet square, covering about $1\frac{1}{4}$ acre. Three counts were taken between noon and one o'clock. The number of squirrels seen out at once was 25, 26 and 25, respectively. Sixty burrows

were counted in this area, so that the infestation was at the rate of 20 squirrels and 50 holes per acre. This is at the rate of $2\frac{1}{2}$ burrows to each squirrel.

On May 28, 1918, a single isolated colony was investigated at a point twelve miles west of Fresno. This colony was in a plowed field which had been planted to grain for several years past. Here, in an area 100 feet square 16 squirrels, eight of which were less than half grown, and 17 burrows were counted. The ratio here was close to one burrow to each squirrel. This figure, again, applies to a period after the close

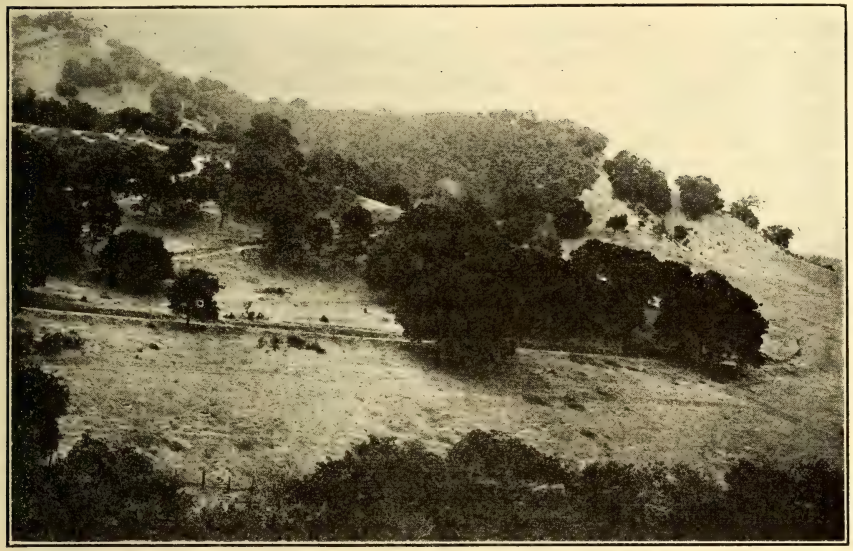

FIG. 16. Hillside near Walnut Creek, Contra Costa County, badly infested with "digger" squirrels. On August 15, 1918, squirrels were here present at the rate of fifty per acre. From this breeding ground they were at this time invading the grain fields on the opposite slope.

of the breeding season, when the squirrel population had reached its maximum.

Counts taken before the breeding season naturally give different results. At Berkeley on March 13, 1918, the junior author counted 47 squirrel burrows in a colony which occupied about one acre on a hillside. By counting the squirrels which appeared aboveground in this area on several successive days it was ascertained that there were about nine adult squirrels inhabiting this acre of ground. This gave an average of over five burrows to each squirrel.

The above-cited instances are based on maximum infestation. Local distribution is often very irregular, since squirrels may be abundant on the southern exposure of a hill and yet be entirely absent on brushy northern slopes only a hundred yards or so distant. Even on the plains and in the valleys, although the distribution is much more uniform, there is often marked unevenness in infestation irrespective of human interference. Surgeon John D. Long (1912, p. 1596), in comparing the cost of the various methods of destroying ground squirrels, based his estimates of cost on an infestation of ten holes per acre. Presumably, this was taken as representing an average infestation according to

the experience of the United States Public Health Service in their eradication work. This appeals to us as a fair estimate on well-populated territory, such as that around San Francisco Bay.

It is the authors' belief that if the entire area in California occupied by this species be taken into consideration a population of one squirrel per acre, or 640 per square mile, at the conclusion of the breeding season, would be a fair average. At this rate there would be a total population of 32,000,000 California Ground Squirrels in the state in July, and one-fourth this, or 8,000,000, in March, before the young of the year are out. If the closely allied Fisher and Douglas ground squirrels be included, as from an economic standpoint might well be done, the "digger squirrel" population of the state in summer, when crops are maturing, may be put at between 40 and 50 millions, in this state.

As for rate of increase, we are dealing with a prolific animal. As already shown, the average size of the litter in the California Ground Squirrel numbers practically eight. Males and females are present in a general population in about equal numbers. Even though but one litter is reared by each female squirrel each year, this would mean that for each pair of squirrels at the beginning of the breeding season there will be ten individuals at the close of the breeding season. The evidence we have examined goes to show that all the squirrels breed the first year of their lives—that is, when each is not quite one year old—as well as subsequently, and that the life-time of a squirrel, if it dies of old age, is five years. If we do not count upon any fatalities, one pair of squirrels can be reckoned on to give origin to a population in five years of 6,250!

In recent efforts to eradicate squirrels a 90 per cent efficiency has been currently estimated. This means that, if no follow-up campaign be waged, ten squirrels out of each original 100 will be left, to form a nucleus of future increase. At the end of the second year the population would be back to normal. Supposing, further, that a follow-up campaign *is* waged at the end of a suitable interval *before* the next breeding season, also with a 90 per cent effectiveness; then only one squirrel per original hundred would be left. Even then, when only six squirrels are left on one square mile, these in the third breeding season will produce, barring normal fatalities, the original 640, with a good margin to spare.

The factors limiting the population of ground squirrels under natural conditions, that is, as not affected by human agency, include the following, in the order of probable importance: (1) Quantity of food available at the season of the year when food is scarcest; (2) natural enemies, including predatory mammals, birds and reptiles; (3) adverse weather conditions, recurring rather infrequently, as when territory is inundated during exceptionally heavy rains; (4) disease; (5) old age. The rate of increase, through long ages, has been adjusted to more than meet the expected death rate from all causes combined. This rate of increase, fourfold each year, is now inherent and we have no reason for expecting any abrupt and permanent change in it either way.

With the arrival of the white man and his accessories in California, the natural balance has been upset. Man has destroyed a large percentage of the natural enemies of the ground squirrel. Cultivation of the land has, on the other hand, in portions of the state improved the food supply. The general tendency is for the squirrels to breed up on

uncultivated land where they are least molested through human agency, and from this they spread out and invade nearby cultivated fields. The process is most conspicuously in evidence during late summer consequent upon the emigration of the young of the year, this being in compensation for the tendency to congestion of population brought on during the breeding season.

Reduction in the food supply locally causes the squirrels to spread out in search of new pastures. Such movements are usually less than a mile in extent, and of course come particularly to notice in the vicinity of grain fields and orchards to which the squirrels drift at the time the crops begin to ripen. Some idea of the rate with which ground squirrels reinfest cultivated fields which are adjacent to wild land may be had from the following instance. Mr. O. N. Garrison of Earlimart, Tulare County, stated in an interview that during the spring of 1918 thirty-six ground squirrels were drowned out on a five-acre field of alfalfa at the first irrigation and this in spite of the fact that the field had been free from squirrels at the end of the previous irrigation season in the fall of 1917.

From the earliest times of which we have record to the present day the California Ground Squirrels have given the impression of abundance. Changes in the status of the species within history have only concerned local occurrence. There is nothing to show that there has been any extension of the general range of the species, or any retraction in it either. As already set forth, the arrival of the white man and the institution of agriculture has undoubtedly had the effect locally of increasing the ground squirrel population. On the other hand, where man has been aroused by the seriousness of their depredations to the point of adopting and putting into force effective means of control the numbers of the squirrels have been conspicuously reduced. Thus at Earlimart on May 16, 1918, ground squirrel burrows were found to be abundant over a large acreage of "hog wallow" land. Live squirrels, however, were exceedingly scarce, only five being found on one tract of forty acres which had been thoroughly poisoned the previous season. A count taken on this tract showed that there was an average of fifty empty burrows to each squirrel present.

A very few localities have been reported in which the squirrels are, for the time being at least, things of the past; but the possibility of re-invasion presents itself, and this, as already shown, may be a very rapid process. It would seem that ground squirrels, like weeds or scale bugs, will have to be watched continually, and proper measures taken whenever necessary to prevent the reinfestation of land which is thought to have been freed.

The difficulties in arriving at a fair estimate of the damage done by the California Ground Squirrel, which is by far the most injurious species in the state, are many and various. We have tried to get at a satisfactory estimate (not a guess) in terms of dollars per annum, but have not succeeded. It may be of some interest, however, to give some other figures, indicative in partial degree of the loss that may be occasioned by this ground squirrel.

In order to ascertain the bearing of squirrels upon grazing interests we have found some basis for estimating squirrels in terms of livestock. We have weighed and examined the stomach contents of a series

of squirrels, with results already given. These, summarized, show that one ounce of dry grain or seeds, or four ounces of green vegetation, is consumed each day by an average California Ground Squirrel. If we take fifty pounds of green stuff as representing the amount of forage consumed daily by one steer on open range, then 200 squirrels would appropriate the forage which would keep one steer. Twenty squirrels would eat as much as one sheep, and this last estimate would be most significant, because sheep graze closer and hence the competition here would be sharpest.

Expressing this relationship in another way, taking the average population of ground squirrels on open range as one per acre or 640 per square mile, the squirrels on each square mile appropriate the forage of three steers or 32 sheep. If the entire range of the California Ground Squirrel be taken into account and be supposed to consist purely of grazing lands (and so of minimum land value) grazed to their fullest capacity, then the squirrels of this species take the place of 160,000 cattle or 1,600,000 sheep. Of course, it is not likely that the squirrels come into actual close competition with livestock in ordinary years; but in extra dry years, such as that of 1917-18, when all the living things which depend on vegetation for support are hard pressed to maintain existence, then the squirrels cannot help but crowd the cattle interests of the country, which are of such vital human importance.

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## FISHER GROUND SQUIRREL.

### Citellus beecheyi fisheri (Merriam).

PLATE V.

**Other names.**—Fisher Spermophile; Digger Squirrel, part; *Spermophilus beecheyi*, part; *Spermophilus beecheyi fisheri; Spermophilus grammurus fisheri; Citellus variegatus fisheri; Citellus grammurus fisheri; Otospermophilus beecheyi fisheri; Spermophilus grammurus beecheyi*, part.

**Field characters.**—As for the Beechey Ground Squirrel, differing in paler tone of general coloration, and in more extensive and purer white shoulder patches. Length of body alone about 9¾ inches, with tail about 6 inches more.

**Description.**—In all pelages: Closely like *beecheyi*, except for pallid tones of color predominantly light cinnamon-drab, and extension of light areas. The shoulder patches in typical *fisheri* are much clearer white and tend to meet on the fore back between the shoulders; in some specimens the mid-dorsal grayish brown stripe is almost obliterated by these white invasions. The back of the ear is usually grizzled buffy in *fisheri* instead of chiefly black, and its hinder margin and base are silvery white. The lower surface of the body and the upper surfaces of the feet are usually much whiter, less buffy, than in *beecheyi*.

**Color variations.**—The range of individual and seasonal variation in *fisheri* seems to be about the same as in *beecheyi*.

The extreme of the characters of *fisheri* are developed in the Inyo region, and gradual intergradation or blending takes place towards *beecheyi* chiefly through southern Tulare and Kern Counties. The dotted line on the map (fig. 17) separating the ranges of *fisheri* and *beecheyi* represents no place of abrupt demarcation but only somewhere near the middle of the belt of intergradation. Many individuals from the vicinity of this hypothetical line are so nearly betwixt typical *beecheyi* and typical *fisheri* that they can only arbitrarily be placed under one name or the other. This has been done with such intermediate examples in the lists of specimens examined.

**Measurements.**—Average and extreme measurements, in millimeters, of thirteen mature specimens from Inyo County are as follows: Five males: total length, 417 (400–455); tail vertebræ, 163 (155–180); hind foot, 57 (50–65); ear from crown, 19 (16–22); greatest length of skull, 55.4 (54.1–57.0); zygomatic breadth, 34.7 (33.3–36.3); interorbital width, 13.3 (13.1–13.9). Eight females: total length, 396 (374–417); tail vertebræ, 157 (145–170); hind foot, 53 (51–55); ear from crown, 19 (18–23); greatest length of skull, 53.9 (52.3–55.7); zygomatic breadth, 33.2 (31.0–34.7); interorbital width, 13.2 (12.2–14.3).

The above figures show that the race *fisheri* is decidedly smaller in almost every particular than *beecheyi*. The disparity between the sexes is quite as well shown, however, and the rest of the variable features seem to be exhibited in about the same degree, making due allowances for the smaller number of *fisheri* measured.

**Weights.**—Average and extreme weights in grams of eight mature specimens from Inyo County are as follows: Five males, 589 (480–656); three females, 400 (321–440). Averages in ounces: males, about 20¾; females, about 14.

It is probable that a larger series of weights would give somewhat different averages. That for the females seems low.

**Type locality.**—Kern Valley, 25 miles above Kernville [= South Fork of Kern River 25 miles east of Kernville], Kern County, California (Merriam, 1893, p. 133).

**Distribution area.**—Roughly the western borderlands of the Mohave Desert, north into the Inyo region and south as far as the northwestern arm of the Colorado Desert. More in detail, the western side of Owens Valley including the adjacent east slopes of the Sierras north to the vicinity of Mammoth Pass; east from the southern end of Owens Lake through the Coso, Argus and north end of the Panamint Mountains; the extreme southern Sierras, including the entire drainage basin of the Kern River; the southern end of the San Joaquin Valley south of Tulare Lake, and the Carrizo Plains country and adjacent hills and valleys to the westward; the Tehachapi, Tejon, San Bernardino, San Jacinto and Santa Rosa Mountains and adjacent desert borders. The approximate line of blending between the races *beecheyi* and *fisheri* is shown on the map (fig. 17). With regard to life-zone the Fisher Ground Squirrel extends from the Lower Sonoran to the Canadian but its greatest numbers are reached, and most of its habitat lies, in the Upper Sonoran (see fig. 23).

**Specimens examined.**—A total of 96 specimens from the following localities, all in California: Inyo County: Little Onion Valley, 7,500 ft., east slope Sierra Nevada west of Independence, 1; Independence, 4; vicinity of Lone Pine, 3; vicinity of Jackass Spring, 6,200–6,500 ft., northern part of Panamint Mts., 9; Little Lake, 2; Olancha, 1; Little Cottonwood Creek, at 10,000 ft. alt., 1. Tulare County: Jordan Hot Springs, 6,700 ft., 1; Jackass Meadow, 7,750 ft., 1; Trout Creek, 6,000 ft., 3; Taylor Meadow, 7,000 ft., 5; Cannell Meadow, 7,000 ft., 1; Earlimart, 2; Tipton, 5. Kern County: Kern River, seven miles above Kernville, 1; Fay Creek, 4,100 ft., 2; west slope Walker Pass, 4,600 ft., 3; Weldon, 1; Isabella, 2; Bodfish, 1; Kern River, twelve miles below Bodfish, 1; eight miles northeast Bakersfield, 1; San Emigdio, 2; Fort Tejon, 5. San Luis Obispo County: near Simmler, on Carrizo Plains, 1. Ventura County: Mount Pinos, 3. San Bernardino County: Victorville, 2; Cushenbury Springs, 1; Doble, 7,000 ft., San Bernardino Mts., 1; Bluff Lake, 7,500 ft., San Bernardino Mts., 2; Fish Creek, 6,500 ft., San Bernardino Mts., 1. Riverside County; near Banning, 1; Cabezon, 9; Snow Creek, near Whitewater, 1; Schain's Ranch, 4,900 ft., San Jacinto Mts., 4; Fuller's Mill, 5,900 ft., San Jacinto Mts., 1; Round Valley, 9,000 ft., San Jacinto Mts., 1; Tahquitz Valley, 8,000 ft., San Jacinto Mts., 1; Strawberry Valley, 6,000 ft., San Jacinto Mts., 9.

The Fisher Ground Squirrel is closely related to, and in general very much like, the California Ground Squirrel with which it blends in Kern and Tulare Counties. In general appearance the former is slightly smaller and decidedly paler than the latter. The Fisher Squirrel may be recognized in the field by its extensive white shoulder patches. This sub-species is also known as "digger" squirrel.

The range of the Fisher Squirrel includes Kern Valley and part of Owens Valley, the extreme southern part of the San Joaquin Valley, and a strip of territory along the northern and western edges of the

Mohave Desert from the mountains east of Owens Lake south to the Santa Rosa Mountains west of Salton Sea.

In altitude this squirrel ranges from 450 feet, as at Palm Springs at the eastern base of San Jacinto Peak, to 10,500 feet, as within a quarter of a mile of the summit of the same mountain (H. S. Swarth, MS). It is to be found from the southernmost plains of the San

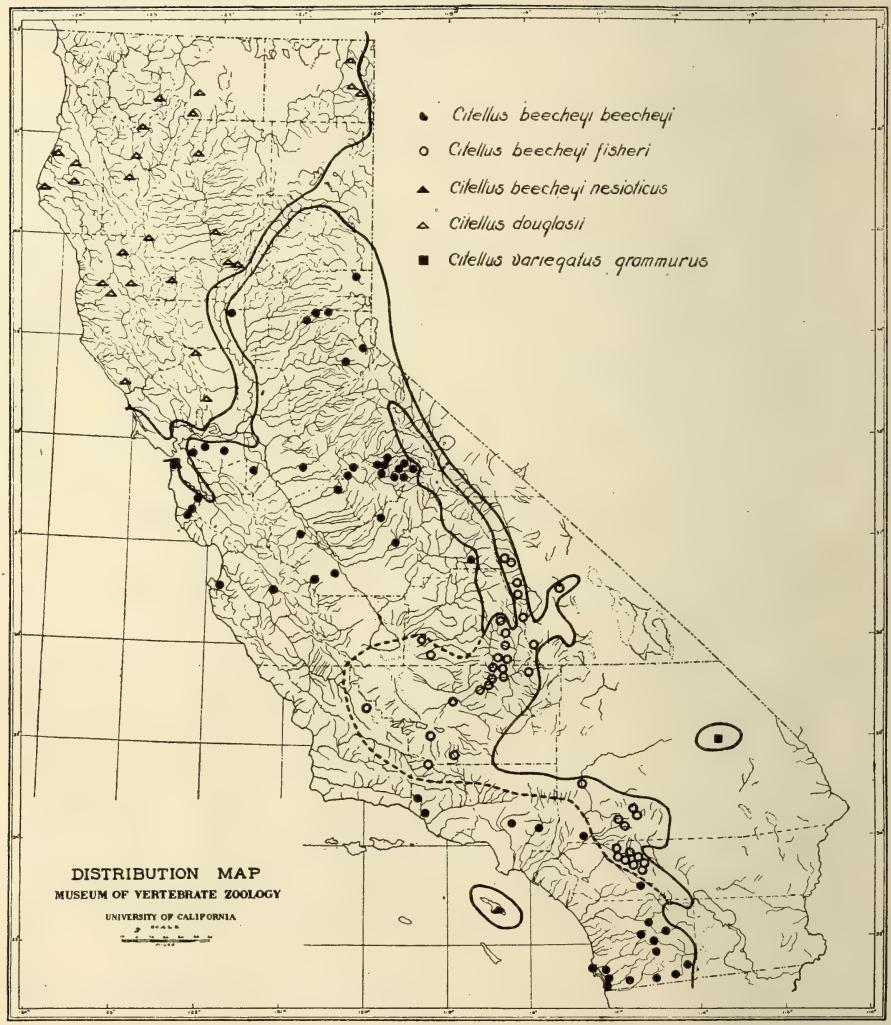


FIG. 17. Map showing California distribution of the California, Fisher, Catalina Island and Douglas ground squirrels, and the Rock Squirrel, all being of the "digger" category. The spots represent localities from which actual specimens have been examined.

Joaquin Valley to 10,000 feet altitude in the Mount Whitney region. This rodent thus shows little regard for zonal limitations, occurring all the way from the Lower Sonoran zone to the Canadian zone, though its numbers above the Upper Sonoran are small. It is equally at home

in the cultivated fields in the irrigated sections, about Bakersfield and on the rocky ridges of the Panamint Mountains.

At Jackass Springs, in the Panamint Mountains, Inyo County, on October 5, 1918, eight Fisher Ground Squirrels were counted in a three-hour census in the belt of sagebrush and piñon. These were invariably perched upright on the summits of gray granite boulders. They were even then notably pale-colored, with *beecheyi* in mind (J. Grinnell, MS).

At Mount Pinos, Ventura County, during the first week in July, 1904, Fisher Squirrels were present from the very summit (8,826 feet) down. They were trapped among the rockpiles near the top, and on the smooth slopes among the firs on the north side. Young were numerous, and quite unsuspicious, being run down with ease when caught a little ways from their retreats (J. Grinnell, MS).

Near Lone Pine in Owens Valley on June 16, 1917, Fisher Ground Squirrels were found inhabiting the lower embankment of the Los Angeles Aqueduct. At one point three miles south of Lone Pine, some thirty squirrels were noted along the aqueduct in a distance of half a mile. Other colonies were found along Lone Pine Creek at the edge of an old orchard (A. C. Shelton, MS).

In the region about Bakersfield Fisher Squirrels were found in considerable numbers near the mouth of Caliente Creek east of Bakersfield both in the wheat fields and on the adjoining plains covered with a low growth of cactus. In the irrigated region southwest of that city the squirrels were locally numerous on pasture land.

The Fisher Ground Squirrel as far as we can see is indistinguishable from the California Ground Squirrel in many particulars such as behavior, voice and mannerisms. This statement applies also to the general feeding and breeding habits of the form. Many incidents bearing on such points as enemies and natural checks have been recounted in our chapter relating to *beecheyi,* since they are for the most part identical in the two races.

Certain instances of behavior in the desert race seem worthy of special mention. At Isabella, Kern County, on July 4, 1911, W. P. Taylor (MS) states that it was a common thing to see the squirrels up from the ground in guatemotes or willows. At Palm Springs, Riverside County, on February 4, 1916, two Fisher Squirrels were seen to leap an irrigation ditch near town, a clear jump of about four feet (H. S. Swarth, MS). Sometimes individuals of this species do not hesitate to jump into water and swim, so as to escape from enemies. At Onyx, Kern County, on June 19, 1911, a half-grown squirrel was surprised on the bank of an irrigation ditch which was full of water. The stream was six feet wide, with rapid current. Without the least hesitation, the squirrel precipitated itself into the water and swam across, reaching the opposite shore by a diagonal down-stream course. It then quickly ran to a burrow, with the location of which it seemed familiar and from which it is likely to have come originally and crossed the ditch of its own accord for the purpose of foraging (J. Grinnell, MS).

The time of birth of the young in this species varies with altitude, more precisely zone, from April to late in June. At Cabezon, Riverside County, a one-third grown young one was secured May 16, 1908,

while at 8,500 feet on Mount Pinos, Ventura County, a similar sized young one was taken July 11, 1904. At the former locality three juveniles and an adult female were drowned out of one community burrow in an almond orchard. This is probably about the minimum number in a litter, as the average number of young in a litter appears to be only slightly less than in the California Ground Squirrel. "The average number . . . of young at a birth . . . along the borders of the Mohave Desert appears to be . . . 6 or 7" (C. H. Merriam, 1910, p. 4). At Schain's Ranch, San Jacinto Mountains, on June 18, 1908, a family of eight young ground squirrels was observed aboveground at one time at the mouth of a burrow (W. P. Taylor, MS).

Regarding food preferences of this sub-species a special feature has been noted with extraordinary frequency, as follows. Many Fisher Ground Squirrels are taken in meat-baited steel traps set for predatory carnivores under circumstances which make it seem certain that they were caught while trying to steal the bait. They have also been known to eat woodrats and even other individuals of their own kind which they have found dead in traps.

At Kelso Pass, Kern County, on July 8, 1911, two Fisher Ground Squirrels came to drink at a seepage from a spring. One drank six times, the fifth time for over two minutes, by count of seconds (J. Grinnell, MS).

The following records of cheek-pouch contents establish some of the sorts of food taken by this animal. At Taylor Meadow, Tulare County, a squirrel was taken on July 25, 1911, with 88 seeds of a lupine (*Lupinus grayi*) in its cheek-pouches. Another squirrel taken seven miles above Kernville, Kern County, on June 26, 1911, was carrying a seed of the Digger Pine (*Pinus sabiniana*); while a third squirrel taken at Lone Pine, Inyo County, had gathered and placed in its cheek pouches 118 seeds of *Encelia frutescens* and 5 seeds of *Hymenoclea salsola.*

Squirrels of this subspecies were found doing a large amount of damage to the almond crop at Cabezon, Riverside County, on May 16, 1908. Here they were living right in the almond orchard, most of the inhabited burrows being dug close to the roots of the trees. Other short, shallow burrows were noted, but these were thought to be of use only for temporary protection in case the animals were taken by surprise (C. H. Richardson, MS).

In Antelope Valley, near Fairmont, Los Angeles County, on June 22, 1904, the authors found ground squirrels doing enormous damage to almonds, climbing the trees and biting open the green fruit to take out the pit and often leaving the hull in place on the tree. The pit was frequently found to have been removed from a remarkably small hole in the side or end of the shell.

At various points within the range of *fisheri* we have been told by old residents that digger squirrels have only recently invaded the locality and that a few years ago there were none where many squirrels are now present. In many such cases the sudden increase in the number of ground squirrels is evidently due not to invasion from without, but to the breeding up, under favorable conditions, of the local stock of squirrels which have been present all the time, but which was formerly so

small and scattered that it did not attract attention. A typical example is as follows.

Residents of Owens Valley at Lone Pine stated in June, 1917, that the ground squirrels there had only recently invaded the valley and that none were known in that vicinity five years before. But from this same locality specimens now preserved in the Field Museum of Natural History in Chicago were obtained in 1902, fifteen years previously. Although the squirrels are said to be steadily increasing along the west side of Owens Valley, little or no effort appears to have been attempted at controlling the pest.

At the Carl Walters Ranch, two miles north of Independence, on June 26, 1917, Fisher Ground Squirrels were found to be fairly abundant on both this and most of the other ranches in the vicinity. They had been considered a nuisance here for a number of years (A. C. Shelton, MS).

The irrigation and cultivation of extensive areas have resulted in a greatly increased available food supply which has proven acceptable to the ground squirrel and has resulted in greatly increasing its population. It is the authors' belief that the squirrels have been present in Owens Valley from time immemorial and that as long as they were few in numbers and stuck to the rocky, uncultivated ground they remained largely unnoticed, but that when they invaded irrigated fields and became numerous they attracted attention and were then thought to have but just moved into the valley.

It is believed that, on the whole, there are only about half as many Fisher Ground Squirrels to the square mile throughout its range as there are California Ground Squirrels to the same unit of area in the range of that form. Fisher Squirrels nevertheless prove very destructive locally to cultivated crops. Many small isolated orchards and "dry-farmed" grain fields are scattered throughout the western and northern parts of the range of *fisheri* and these frontier ranches are the ones which suffer. While the money value of the crop destroyed may be small, yet such crops are often the settler's principal means of obtaining a livelihood and, although this may be humble indeed, its loss is felt critically. It is the authors' belief that the Fisher Ground Squirrel ranks third, or next after the Oregon Ground Squirrel, in point of economic importance in California.

## CATALINA ISLAND GROUND SQUIRREL.

### Citellus beecheyi nesioticus Elliot.

**Other names.**—Island Spermophile; *Citellus nesioticus; Spermophilus beecheyi*, part.

**Field characters.**—As for the Beechey Ground Squirrel. Only to be distinguished from it on comparison of series of specimens; coloration averaging darker, general size greater, and tail relatively shorter. Length of body alone, in males, about 11½ inches; with tail (without hairs) about 7½ inches more.

**Description.**—Adults in April: Similar to the Beechey Ground Squirrel (San Francisco Bay region) as already described, but general coloration darker; top of head from nose to nape, and broad area down middle of fore back between light



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shoulder patches, deep cinnamon-brown, the hairs individually being black, tipped with cinnamon; middle of back darker in tone than top of head; spot above upper eyelid blackish; cheeks and sides of neck much darker in tone than in *beecheyi;* whitish shoulder patches, restricted in exten', dull and indistinct as compared with *fisheri* and *douglasii*, even more so than in *beecheyi*. Under surface of body very dark in tone, the hairs extensively grayish bister at bases and tipped with cinnamon buff. Tail and feet colored as in *beecheyi*.

**Color variations.**—The type and one other specimen show a black patch on the crown, due to lack of cinnamon hair-tippings; this, of course, is merely an individual feature.

The May-taken series at hand shows various transition stages from winter to summer pelage. In most of the specimens the fore parts are in fresh harsh summer coat, while the rump is still covered with the winter coat, showing underfur, and being more or less worn and faded. The tail in some examples is markedly worn and faded, with the usually resulting changes in color. In some specimens the hairs of the tail show but two dark bands instead of three; but this variation occurs also in other near-related races of ground squirrels. The two skins taken in February are in full winter pelage, showing more or less underfur over the whole body and no signs of molt. The fore parts, as compared with the summer pelage, are less bright in color tones, and the shoulder patches are even less distinctly whitish. Hinder upper surface and tail exactly as in *beecheyi* of same season.

**Measurements.**—Average and extreme measurements, in millimeters, of nineteen full-grown specimens from near Avalon, Catalina Island, are as follows: Seven males: total length, 471 (447–495); tail vertebræ, 189 (175–200); hind foot, 59 (55–63); greatest length of skull, 60.2 (56.1–63.7); zygomatic breadth, 36.9 (33.8–39.2); interorbital width, 14.8 (13.3–15.9). Twelve females: total length, 444 (406–475); tail vertebræ, 179 (161–194); hind foot, 56 (53–62); greatest length of skull, 57.7 (54.0–62.4); zygomatic breadth, 35.9 (33.3–37.6); interorbital width, 14.3 (13.0–15.4).

Close examination of the series of skulls shows to us no character by which to tell them from *beecheyi* or *fisheri* except for average greater size. There is the usual range of variation in proportions, due to age, this factor being judged from degree of wear on the crowns of the molariform teeth. Old skulls are largest, broadest relatively to length, and with most prominent ridges and processes. It is difficult for us to understand how Elliot (1904, p. 263) could have assigned the numerous cranial characters he did to the form he named, except on the ground that he examined but a very few specimens of *beecheyi* and *fisheri* and that these happened to be extreme.

**Type locality.**—Santa Catalina Island, California (Elliot, 1904, p. 263); more exactly, vicinity of Avalon, according to the collector of the type, Mr. John Rowley, in interview.

**Distribution area.**—Santa Catalina Island, California. Life-zone, Upper Sonoran.

**Specimens examined.**—A total of 21 skins and skulls, all from the vicinity of Avalon, Catalina Island. Two of these (including the type) were loaned us from the Field Museum of Natural History, Chicago; and nineteen were loaned us from the Museum of History, Science and Art, Los Angeles.

Only three species of rodents are known to be native to Catalina Island, a harvest mouse, a white-footed mouse, and the Catalina Island Ground Squirrel. This last-named animal is, as in each of the other cases, but slightly differentiated from its counterpart on the adjacent mainland. With little doubt it differs no more from its near relative, the Beechey Ground Squirrel, in general habits and traits, than it does in structure.

Until the present year very little has been known of the Catalina Island Ground Squirrel. In fact, the original characterization of the race was so unsatisfactory as to leave doubts in the minds of some students as to whether the island animals really differ at all from the

mainland ones. Fortunately for the present writers, our appeal to Mr. Frank S. Daggett, Director of the Museum of History, Science and Art, in Los Angeles, was promptly met by action, and Mr. L. E. Wyman of Mr. Daggett's staff was detailed to go to Catalina and obtain a sufficient number of specimens for deciding the doubtful questions. Mr. Wyman was eminently successful, and the resulting series of skins and skulls, together with the accompanying information, was freely placed at our disposal for use in connection with the present paper.

Mr. Wyman found the squirrels fairly swarming May 9 to 16, 1918, at the upper end of a narrow tract of bottom land about a mile back of Avalon. This tract, dotted with elderberry trees, had been seeded to barley, and the grain stood knee-deep except in the spots where it had been persistently eaten down by the squirrels. The hillside adjoining on the northwest was steep and fairly well covered with cactus and chaparral, and in places it was honeycombed with burrows. The bottom of the hill was beset with extensive diggings every fifty feet or so.

Besides the barley, the squirrels were feeding on a variety of wild vegetation. Each of the numerous stomachs examined contained a well-chewed green mass. Cheek-pouches were found to contain barley blades and certain seeds, and in one case four bulbs of "sour-grass" or "grass-nuts" (*Brodiæa capitata*), the largest of which was half an inch in greatest diameter. These bulbs seem to be specially sought after, as several small areas were found, usually on south-fronting grassy hillsides, where the ground was all dug up by the animals, and hulls of Brodiæa bulbs were lying about.

One ground squirrel was seen at work in a wild tobacco tree about seven feet from the ground. He had gnawed at the stem near the top until only a shred kept it from dropping. Gnawed shells of chilicothe seeds were also found.

Mr. Wyman believes that the notes and actions of the Catalina Island Ground Squirrel do not differ to any appreciable extent from those of the mainland Beechey. The island animals were perhaps slightly less noisy, though when once started to barking they seemed hardly able to stop. They were found to be shy on open ground, hustling to cover when the invader of their domain was yet 200 yards off. By sitting quietly under a tree, however, Mr. Wyman had one squirrel approach him to within ten yards and feed on barley shoots. On the brushy hillsides, the collector was able to stalk his quarry with ease.

All the females taken were notably fat, and none contained embryos. Also no young of the year were seen; so that it would seem that the breeding season of the island squirrel is much later than that of the mainland animal—later, at least, than May 16. Every specimen taken by Mr. Wyman was "loaded with fleas;" these, however, quickly disappeared and in no case caused any annoyance to the collector.

Since ground squirrels were seen by the senior author commonly in August, 1903, in the vicinity of the Isthmus, near the northwest end of Catalina, it may be inferred that the animals are widely distributed over this island. No species of ground squirrel whatever exists native on any of the other California islands.

## DOUGLAS GROUND SQUIRREL.

## Citellus douglasii (Richardson).

PLATE II.

**Other names.**—Douglas Spermophile; Digger Squirrel, part; *Arctomys douglasii; Citellus douglasii; Citellus variegatus douglasii; Spermophilus grammurus douglasii; Spermophilus douglasii; Citellus beecheyi douglasii; Spermophilus grammurus beecheyi*, part; *Citellus grammurus douglasii.*

**Field characters.**—As for the Beechey Ground Squirrel, from which differs noticeably in the possession of a blackish brown wedge-shaped patch on the fore part of the back; also shoulders more extensively silvery white, and tail longer. Length of body alone, in males about 11 inches, with tail about 8 inches more.

**Description.**—Adults in early summer pelage: Crown of head to nose buckthorn brown, becoming mixed with blackish toward eyes and ears; backs of ears deep bister brown margined behind broadly with clay color; insides of ears dull cinnamon-buff; eyelids white; whiskers black; side of head and of body behind shoulder deep bister brown, with much buffy white tippings to hairs; a conspicuous wedge-shaped patch on middle of fore part of back, with apex at nape of neck, solid deep bister brown in color, almost black in some specimens; shoulder patch extensively silvery white, this extending backwards to hinder end of median dark wedge. Hinder portion of body colored as in the Beechey Ground Squirrel, but dappling more conspicuous, due to the whiter tone of the light spots. Under surface of body of darker tone than in *beecheyi*, seemingly due to the darker, sepia brown, bases of the hairs showing through the dull white or buffy overwash. Feet as in *beecheyi* but clouded above with dusky. Tail colored as in *beecheyi* but light tippings to hairs greater in extent and whiter in tone, thus accentuating the white fringe, and producing a grayer effect throughout.

**Color variations.**—Young but a third grown usually show the characters of the species, both as to color and relative tail length, quite as well as do adults. In one example, however, the black dorsal wedge is considerably obscured by buffy mottlings, and it thus resembles *beecheyi* of the same age.

The effects of wear and fading rarely bring such extreme modification of color tones in *douglasii* as in *beecheyi* and *fisheri*, possibly due to the lesser intensity of the sunlight and dryness to which their habitat is usually subject. The black wedge on the fore back is most vivid in fresh pelage; in cases where wear and fading have progressed to an extreme degree, the black wedge is much dulled toward brown, and may be effaced almost entirely. The identity of the ground squirrels in any given locality can be determined with certainty by securing several individuals, when the normal, distinctive coloration is sure to be shown by some of them.

**Measurements.**—Average and extreme measurements, in millimeters, of seventeen full-grown specimens from the northwestern counties of California (Sonoma to Humboldt) are as follows: Twelve males: total length, 478 (438–504); tail vertebræ, 200 (175–221); hind foot, 60 (57–63); ear from crown, 23 (19–29); greatest length of skull, 60.5. (57.8–63.1); zygomatic breadth, 37.0 (34.9–38.2); interorbital width, 14.3 (13.5–15.7). Five females: total length, 439 (427–453); tail vertebræ, 192 (161–210); hind foot, 57 (56–60); ear from crown, 23 (18–26); greatest length of skull, 58.5 (56.8–60.4); zygomatic breadth, 35.9 (35.0–36.8); interorbital width, 14.0 (13.1–15.0).

Always taking age into account, there appear to be fairly diagnostic average skull characters for *douglasii* as compared with *beecheyi, fisheri* and *nesioticus*. *Douglasii* averages smaller in regard to auditory bullæ, and narrower as regards rostrum and braincase. Yet, as the above measurements show, the gross size of the skull is not especially different.

**Type locality.**—Probably somewhere in southern Oregon or northern California. The type was a hunter's skin "received from the banks of the Columbia" (Richardson, 1829, p. 172).

**Distribution area in California.**—Roughly, the northwestern section of the state, north of San Francisco Bay, west of the lower Sacramento River, and north of a diagonal line from near Chico northeast to the Nevada line near the southern

OREGON GROUND SQUIRREL (AT LEFT); DOUGLAS GROUND SQUIRREL (AT RIGHT).

boundary of Modoc County. (See map, fig. 17.) Life-zone, Upper Sonoran and Transition, ranging down into Lower Sonoran along the western side of the Sacramento Valley. Altitudinally, the species ranges from near sea level up to as high as 6,500 feet (near South Yolla Bolly Mountain) and even 6,800 feet (on the Scott Mountains, Siskiyou County).

More in detail: The southern limit of the range of *douglasii* is not known to reach the Golden Gate; it falls, on the sea-coast, somewhere not far to the north of Point Reyes Station, and extends from there to the vicinity of Petaluma, leaving the southern two-thirds of Marin County uninhabited. It extends nearly or quite to Benicia and to the southern end of the range of hills west of Vacaville. The flood-plain of the Sacramento River forms the eastern boundary north to beyond the Marysville Buttes. Thence northeastward, across the Sacramento Valley, there is no obvious barrier. In Butte, Plumas and Lassen Counties the ranges of *douglasii* and *beecheyi* approach very closely, but so far as known they do not overlap; nor have undoubted hybrids or geographic intergrades been reported.

**Specimens examined.**—A total of 65, from the following localities in California: Modoc County: Sugar Hill, 3; Parker Creek, Warner Mts., 3; Deep Creek, Warner Mts., 1. Siskiyou County: Mayten, 1; six miles northwest of Callahan, Scott River Valley, 6; Summerville, 1; Castle Lake, 3. Shasta County: McCloud River, near Baird, 7. Tehama County: Mill Creek, 2 miles northeast of Tehama, 4; four miles south of South Yolla Bolly Mountain, 1. Butte County: four miles southeast of Chico, 4; Dry Creek, on Oroville-Chico road, 3. Glenn County: Winslow, 4. Yolo County: Rumsey, 1. Solano County: three miles west of Vacaville, 2. Humboldt County: Eureka, 1; Fair Oaks, 2; Ferndale, 1; Cuddeback, 1. Trinity County: Hayfork, 2; Helena, 2. Mendocino County: Sherwood, 3; three miles south of Covelo, 1; six miles north of Willets, 1; Mount Sanhedrin, 3. Sonoma County: seven miles west of Cazadero, 4.

The Douglas Ground Squirrel belongs to the group of large, bushy-tailed, tall-eared ground squirrels which include the California, Fisher, Catalina Island and Rock Squirrels, and in common with the first and second of these at least it is often called Digger Squirrel. Although the differences are not great, they are evident and should be recognized in economic work, for they not only concern color, but apparently also habitat and food preferences. The Douglas Squirrel differs from its next neighbor of the "digger" category, the California, in having a conspicuous blackish wedge-shaped patch on the middle of the back between the shoulders, in having the shoulder region more extensively grayish white, and in having the tail a little longer and grayer.

The name of the squirrel now under discussion was bestowed upon it (Richardson, 1829, p. 172) in acknowledgment to an early English explorer in western America, David Douglas, for having brought home specimens of the animals met with, many of which proved to be new to science. Douglas's travels carried him through parts of Oregon and probably northern California; but the type of this ground squirrel was a hunter's skin received from the Columbia River. There is no telling now exactly where it really came from originally, though probably from much south of the Columbia, since the species is not known to have existed within history that far north.

In northern California the Douglas Ground Squirrel occupies a wide area; in fact, at the extreme north from the Pacific Ocean to the Nevada line. To the southward its range includes all of the upper Sacramento Valley, and its western half lower down, and the whole coast region (hills and included valleys) south nearly to San Francisco Bay. Reference to the map (fig. 17) will show that the range of the Douglas is almost exactly complementary to that of the Beechey; at no point do

they overlap, or, indeed, as far as known, quite meet. Roughly, the Douglas Ground Squirrel occupies the northern and northwestern third of the state.

The local or habitat preference of this species is more exclusively for hilly country than in the case of the California Ground Squirrel. It is true that the Douglas exists out on the floor of the Sacramento Valley nearly to the lands annually flooded along the river; but it occurs there interruptedly, in far separated "colonies," and never anywhere are the great numbers reached that characterize *beecheyi* in the San Joaquin Valley. The preferred haunts of *douglasii* are the openings or glades on hillsides, beneath scattered oaks or pines, or else the open tracts along stream courses, not, however, quite down to the water's edge. The edges of the smaller valleys between the coast ranges are well populated, but the open floors of these valleys are not often invaded very far or in any considerable numbers. Dense chaparral and thick woods are avoided altogether.

It is interesting to note here that where the coast redwoods have been lumbered out the Douglas Ground Squirrels have come in from the interior so as to be plentiful where formerly scarce or wanting. Chaparral slopes which have been swept by fire are also quickly invaded and occupied for a time, until the brush grows up thickly again. It is probable that the squirrels are unable to maintain themselves against enemies, such as bobcats, that habitually hunt by stealth through underbrush; the squirrels require a certain amount of space around them so that they can have a fair show of reaching the safety of their burrows after an enemy is first caught sight of. Even though the Douglas Ground Squirrels are nowhere so very numerous as compared with certain other rodents, their predilection for clearings brings them into economic prominence locally. We have been told repeatedly of cases where newly cleared farms in mountain valleys have been invaded at harvest time from the nearby hillsides, to the almost complete loss of the crops.

It is a curious thing that the Douglas Ground Squirrel should not occur south clear to the shores of San Francisco Bay, inasmuch as the Beechey on the south side of the bay extends up to either the very shore line itself or to the margin of the salt marshes adjacent, or did so until very recent years. This may be merely another indication of the lesser degree of aggressiveness or prolificness on the part of the Douglas Squirrel. Marin County seems to be devoid of any ground squirrels whatsoever, except for a few *douglasii* along the Sonoma County border. Joseph Mailliard (interviewed on May 8, 1918) states that in his forty years or more of residence in Marin County, he never saw any ground squirrels in the southern part or westwardly towards Point Reyes. Individuals were seen twice many years ago on the Rancho San Geronimo, but "they never stayed." To all appearances the conditions here are identical with those in the Russian River district and a few miles west of Petaluma where the animals in question are plentiful, or used to be until successfully combated.

Within the California portion of its range the Douglas Ground Squirrels are believed to be most numerous in Tehama County, this according to the consensus of opinion in the office of the State Superintendent of Rodent Control. In Shasta County, next on the north, there are rela-

tively few. To the westward they extend within a mile of the seacoast in the vicinity of Eureka and at Cape Mendocino, but elsewhere mostly not closer to the sea than eight or ten miles. Nowhere in the immediate coast belt are they reported especially numerous or injurious. Pocket gophers there loom up as the most destructive rodent.

The voice and mannerisms of the Douglas Ground Squirrel are not to us in any points that can be remembered materially different from those of the California Ground Squirrel. A fair test of this could, of course, only be made upon the two if studied side by side under perfectly normal conditions. In the nature of the case this is impossible, for in no known locality do they occupy common ground.

The tail is at all times the most conspicuous feature of this ground squirrel. Sometimes when running to its burrow a squirrel will hold its tail in a continuously vertical position, or this member may be thrashed fore and aft. Ordinarily the tail is held nearly parallel to the ground, with more or less of an arch in it. In this posture of tail one is reminded strongly of the Gray Squirrel.

Our own observations, and the testimony of people in general who are familiar with several of our ground squirrels including the Douglas, indicate that the latter is the most prone of all to climb trees. For instance, near Tehama, June 8, 1912, several individuals were seen well up in large white oaks (W. P. Taylor, MS). At Winslow, Glenn County, June 19, 1912, one was seen in a buckeye, and several from twelve to fifteen feet above the ground in willows and cottonwoods (W. P. Taylor, MS). At Sisson, Siskiyou County, August 11, 1914, one was seen thirty feet above the ground in an incense cedar (T. I. Storer, MS). It is a common thing to see them perched upon the tops of fence posts or stumps. Individuals may under certain circumstances so nearly resemble Gray Squirrels as to be actually mistaken for them. This emphasis of the tree-climbing habit in the Douglas Ground Squirrel is, suggestively enough, thus associated with greater length of tail and grayer tone of color of tail, as compared with its nearest relatives. It seems, also, that this species, more generally than any other, raids orchard trees such as almond and apricot.

The sure test, on the basis of behavior, of a ground squirrel as compared with any true tree squirrel, such as the California Gray, is that the former, no matter how high in a tree when discovered, will, upon alarm, take to the ground as quickly as possible, and seek safety in a burrow below ground, rather than make off through the branches from tree to tree, or ascend into the uppermost foliage of a treetop. Not infrequently, when surprised in a tree, a ground squirrel will for the time being "freeze" and attempt to escape being seen by remaining motionless. But after being further disturbed and once starting, he makes for the ground by the shortest route.

The burrowing habits of the Douglas Squirrel are similar to those of related species. Steep banks seem to be chosen for burrowing into, whenever available. Many burrows open under rocks, bushes and tree roots. On open, level ground, with no protective shelter at hand, the mouths of the burrows are marked by good-sized mounds, showing the presence of an extensive system below ground. As far as we know, no one has yet made a complete excavation of the burrow system of this species.

The breeding season is indicated by the time of appearance of the young aboveground. In Scott Valley, Siskiyou County, where the species is abundant, very small young were seen abroad on June 8 (1911). At Winslow, Glenn County, young one-fourth to one-half grown were captured on June 16 (1912). At 6,800 feet altitude on the Saloon Creek Divide, in the Scott Mountains, Siskiyou County, July 10 (1911), nursing females were captured, but no young were yet out (L. Kellogg, MS). It is thus probable that at the lower altitudes the young are born during the last half of May, while at the highest levels they are not born until at least a month later. Only one litter is reared each year.

Unfortunately we have no facts of our own to offer in regard to size of litter. We have an idea that fewer young are born each year than in the case of the California Ground Squirrel, judging roughly from the numbers of young seen aboveground, about five. But this is almost pure conjecture. F. E. Garlough, of the United States Biological Survey, is under the impression (interviewed September 7, 1918) that litters in the lowlands average close to eight, while in the mountains five is the usual number. He has known of as few as two and as many as fourteen embryos having been found in pregnant females.

The following definite data on file in the Museum of Vertebrate Zoology show some of the kinds of food selected by the Douglas Ground Squirrel and also the quantity in which each of these kinds may be gathered at one time. A male squirrel taken on Dry Creek where crossed by the Oroville-Chico road, in Butte County, May 31, 1912, contained in its cheek pouches 29 seeds of a wild lupine (*Lupinus micranthus*). Three others taken on Butte Creek, near Chico, June 3 and 5, 1912, contained in their cheek pouches materials as follows: male, 12 seeds of milk thistle (*Silybum marianum*); female, 219 grains of barley and one head of English plantain (*Plantago lanceolata*); female, 142 grains of barley. The cheek-pouch contents of two squirrels taken on Mill Creek, near Tehama, June 12, 1912, consisted of, respectively: female, 121 seeds of bur clover (*Medicago hispida*) and 70 small unidentified seeds, part loose and part in three whole pods; female, 181 seeds of brome-grass (*Bromus carinatus*) and one piece of an acorn. Two squirrels taken in the hills three miles west of Vacaville, July 3 and 6, 1912, contained in their cheek-pouches: female, 29 seeds of Napa thistle (*Centaurea melitensis*) and 30 seeds of bur clover; male, 82 seeds of bur clover, 4 seeds of Napa thistle and one cherry pit. A male taken three miles south of Covelo, Mendocino County, July 20, 1913, held in its cheek-pouches 14 whole fruits and 103 separate seeds of the common manzanita (*Arctostaphylos manzanita*), as also a few small unidentified seeds of two kinds.

From all sources comes the testimony that this species takes barley and wheat with particular avidity. Its storage propensities are highly developed, and it would be interesting to see actual figures as to the quantity of grain garnered underground in one autumn season. Where they invade apricot orchards, as in the foothill district of the Warner Mountains near Alturas, these squirrels climb the trees and take out the pits, discarding the pulp of the fruit.

The Douglas, as is known of most other ground squirrels, is fond of flesh when this can be obtained. Many have been taken in the meat-baited steel traps kept out in various localities for carnivores.

Hibernation seems to be more prevalent with *douglasii* than with *beecheyi,* for all of the population of the former is reported to disappear for weeks at a time, even in the lower valleys. At the higher altitudes, where there is more or less heavy snow, all the squirrels disappear over a period of some months. In Hayfork Valley, Trinity County, the senior author was assured by several different people living there that the Douglas Squirrels hibernate regularly and completely "from November till April." The earliest spring record we have for a mountainous region is of one squirrel caught in a box trap February 25 (1911) near Helena, Trinity County (A. M. Alexander, MS).

The natural enemies of this squirrel probably include practically all those already specified in our chapter on the California Ground Squirrel. Only one specific instance is at hand. A gopher snake found run over in a road near Chico, June 7, 1912, was found to contain in its stomach a young Douglas Ground Squirrel (T. I. Storer, MS). Coyotes are locally reputed to levy considerable toll upon this rodent. We have heard the argument advanced against the poisoning of ground squirrels on wild mountain land in the northwest coast district that reducing the squirrel population will deprive the coyote of one of his chief sources of subsistence and that he will thereupon be forced to seek food elsewhere and so be more prone to raid the poultry of the valley ranches and the flocks of sheep in the mountains. On the other hand, it may be advanced that the total coyote population is adjusted to the total amount of food available at the season of least supply, and that removal of any one important kind of food will in course of time reduce the total coyote population able to exist in any general territory.

A high natural mortality for this species may account for its relative lack of aggressiveness as compared with the California Ground Squirrel. The testimony of a number of people from localities widely scattered over the range of the Douglas Ground Squirrel is to the effect that every few years there is a great reduction in its numbers. Some fairly close observers, forest rangers in the Trinity region, for instance, think this is due to the effects of severe winter weather, as when there is an exceptionally heavy snowfall or torrential rains of unusual amount. In either case the squirrels are thought to be drowned in large proportion when lying dormant underground. Other persons think there are recurrent epidemics of some disease fatal to the ground squirrels. We have no good evidence bearing upon either hypothesis.

Because of this observed reduction in numbers during some winters, certain ranchers have objected to carrying on poisoning operations in the fall, since their efforts might prove to have been unnecessary. They prefer to deal with the naturally reduced squirrel population of the springtime, at the close of the dormant period.

The general range of the Douglas Ground Squirrel has not changed within history as far as definite records show. But, locally, there have been marked fluctuations. On the western side of the Sacramento Valley the animals have been almost completely cleaned out on many large tracts as a result of systematic poisoning. This is particularly true, as we are assured by W. C. Jacobsen, State Superintendent of

Rodent Control, of the Davis, Williams, Willows and Orland districts. The reason for this is twofold: The Douglas Squirrels never did have a secure foothold in the Sacramento Valley, such as the Beechey Squirrels have in the San Joaquin Valley; and the former, according to current impression, takes the poisoned grain more readily.

On the other hand, with the clearing of forest lands in the coast district, through lumbering and homesteading, the squirrels are thought to have extended their confines locally. At any rate, they have become numerous where formerly absent altogether or present in such small numbers as to have been overlooked by the average person.

In certain sequestered valleys among the northern coast ranges we have been assured of a loss to grain crops, where no effort at poisoning the squirrels had been made, of from 5 to 25 per cent. In such cases the squirrel population from the wild land immediately adjacent seemed to have moved in *en masse*, as harvest time approached, to take advantage of the special food supply thus made available. Nevertheless, the Douglas Ground Squirrel, by reason of its relatively sparse population over most of its range, and the ease with which it can be reduced in numbers with reasonable effort, does not rank as of so much economic importance as some other species. We would place it fourth among our ground squirrels, giving precedence to the California, Oregon and Fisher.

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## ROCK SQUIRREL.

### Citellus variegatus grammurus (Say).

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**Other names.**—Plateau Ground Squirrel; Rocky Mountain Ground Squirrel; *Citellus grammurus.*

**Field characters.**—As for the Beechey Ground Squirrel, differing in longer tail and grayer general coloration; fore parts of body continuously grayish white, without specially set-off shoulder patches. Length of body alone about 10½ inches, with tail about 8 inches more.

**Description.**—Summer pelage: Head dull buckthorn brown, grizzled on cheeks and sides of snout; eyelids dull white; whiskers black; backs of ears dull buffy brown, insides of ears pinkish buff. Forward half of upper surface of body light gray, with decided dusky mottling in transverse trend; hinder half of upper surface, of a tawny-olive tone, lighter on sides, and with similar transverse mottling. Whole lower surface of body and upper surfaces of feet, pale pinkish buff, nearly white in some specimens; belly with grayish bases of hairs showing through. Tail considerably bushier than in *beecheyi*, as well as being longer; length of hairs up to 50 mm. (2 inches); tips of hairs more extensively white, thus nearly as in *douglasii;* dark and light intervals on individual hairs same as in *beecheyi*, that is, three dark and four light, the latter including the tipping.

**Color variations.**—Wear and exposure to intense sunshine evidently accounts for the yellowing of the pelage of one specimen at hand; also the tail of the animal shows a curious crinkling of the hairs as if scorched. An adult of date June 2 has the forward half of the body in fresh new (summer) pelage; this is relatively harsh in texture, without underfur. Young less than half grown are colored almost exactly as described above for adults, but the pelage on the under surface is very scanty, so that the bare skin shows through extensively. No winter specimens are at hand from within the state of California.

**Measurements.**—Only two adult specimens are available from California. These are from the Providence Mountains, eastern San Bernardino County, and show meas-

urements, in millimeters, as follows: Male and female (nos. 117301 and 117300, respectively, Biol. Surv. coll., U. S. Nat. Mus.): Total length, 470, 465; tail vertebræ, 194, 205; hind foot, 58, 54; ear from crown, 20, 21; greatest length of skull, 61.2, 58.4; zygomatic breadth, 38.5, 37.0; interorbital width, 15.4, 14.2.

No skull differences of crucial importance between *grammurus* and *beecheyi* are apparent to us in the material at hand for study.

**Type locality.**—Purgatory River, near mouth of Chacuaco Creek, Las Animas County, Colorado (according to Cary, 1911, p. 87). This form was originally described by Thomas Say in 1823.

**Distribution (in California).**—Inhabits the Providence Mountains, in eastern San Bernardino County (see fig. 17); also "the canyons of the Colorado River" (Merriam, 1910, p. 2). Life-zone chiefly Upper Sonoran.

**Specimens examined from California.**—A total of five, all collected by Frank Stephens, June 1 to 3, 1902, in the Providence Mountains, 5,000 to 5,500 feet altitude. These were loaned us from the Biological Survey collection, United States National Museum.

The Rock Squirrel is really a very close relative of the Beechey Ground Squirrel and its habits are doubtless closely similar. It is a wide-ranging form through the southern Rocky Mountain region, stations of occurrence in southeastern California being merely far western outposts. Two of the specimens from the Providence Mountains are young less than half grown; these were taken on June 1, and indicate a breeding date at about the same time of year as for other ground squirrels in the upper Sonoran zone.

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## OREGON GROUND SQUIRREL.

### Citellus oregonus (Merriam).

PLATE II.

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**Other names.**—Oregon Spermophile; Bull Dog; Prairie Dog, part; Gopher; Bobby; Sand Rat; Short-tail; Woodchuck; Belding Ground Squirrel, part; Picket-pin, part; *Spermophilus oregonus; Citellus beldingi*, part; *Spermophilus richardsoni.*

**Field characters.**—A medium sized, short-tailed ground squirrel, of stocky build, and of brownish gray coloration without special stripes or markings of any sort (see fig. 20a). Length of body alone about 8½ inches, with tail about 2½ inches more.

**Description.**—Adult in slightly worn spring pelage: Whole upper surface of a general drab tone of coloration, tinged with cream-buff along sides and with dull cinnamon on top of head and down middle of back. There is usually a faint pattern of fine dappling. Eyelids dull white; whiskers black; ears clothed with short hairs, like top of head in color. Upper surfaces of feet tinged with warm buff; palms naked; soles naked except for sparse hairing forward from heel nearly to tubercles; claws horn-color, dusky at bases. Tail full-haired, flattish, widest about one-fourth way back from end; color on upper surface mostly like back, except for showing through of the hazel bases of the hairs, and for black zone about end succeeded by a buffy white fringe; under surface of tail bright cinnamon rufous, with a broad band of black at end and continuing backwards a little ways along either side, and the whole margined narrowly with buffy white. Under surface of body dull cream-buff, paling on throat and inner sides of legs; much brownish lead-color of the hair-bases shows through on abdomen.

**Color variations.**—As wear proceeds toward an extreme the whole coat becomes grayer, and the cream-buff tints tend to disappear by fading. Males usually remain much less worn than females; otherwise we can see no differences in coloration between the sexes. The material we have shows evidence of but one molt each year,

this beginning about July 1st; but we have no specimens of dates between August and May. It is possible that there is an autumn molt leading into a distinct winter coat. Small young are softer-pelaged than adults, but colored just the same.

**Measurements.**—Average and extreme measurements, in millimeters, of nineteen mature specimens from northeastern California are as follows: Nine males: total length, 275 (260–300); tail vertebræ, 65 (56–80); hind foot, 42 (37–45); ear from crown, 9 (7–11); greatest length of skull, 45.1 (44.2–46.5); zygomatic breadth, 29.1 (27.1–31.0); interorbital width, 10.4 (10.0–11.1). Ten females: total length, 280 (271–292); tail vertebræ, 57 (47–68); hind foot, 43 (41–44); ear from crown, 7.5 (6–8); greatest length of skull, 45.7 (44.9–47.2); zygomatic breadth, 29.7 (29.1–30.4); interorbital width, 10.4 (9.7–10.9).

From the above figures it would seem that, in this ground squirrel, females are larger than males, except for tail and ear. There are chances, however, that measurement of greater numbers would give somewhat different results. It must be kept in mind that the figures taken from the freshly killed animals were supplied by several different people, and method of securing each measurement undoubtedly varies somewhat with the persons doing the measuring. Even with the skulls, all measured by the senior author of this paper, size clearly varies to some degree with age, and the proportions present in our series, of animals of different ages, will naturally affect the average.

**Weights.**—Average and extreme weights, in grams, of six full grown females are: 302 (267–365.8). This average in ounces is about 10½. The heaviest example was notably fat, the lightest, lean. Adipose tissue thus counts importantly in weight, though probably also weight increases, as does size of skull, with age. The animals would probably weigh most just prior to hibernation, as they are then fattest.

**Type locality.**—Swan Lake Valley, Klamath Basin [Klamath County], Oregon (Merriam, 1898, p. 69).

**Distribution (in California).**—Occupies the northeastern corner of the state, comprising the counties of Modoc, Lassen, eastern Siskiyou, and a portion of Plumas (see fig. 18). The metropolis of the species lies in the Upper Sonoran life-zone, but the animals extend through Transition, and even enter the Canadian. In detail: west from the Nevada line as far as the vicinity of Goose Nest Mountain, Siskiyou County, and vicinity of Big Meadows, in extreme northern Plumas County; south from the Oregon line to the last named locality and to the valley of Susan Creek, in Lassen County. Altitudinally, this ground squirrel extends from as low as 3,300 feet, on the Pit River, up to 9,000 feet, on Warren Peak, Warner Mountains (Mus. Vert. Zool.).

**Specimens examined.**—A total of 51 from the following localities in California: Modoc County: Sugar Hill, 4; Goose Lake near Davis Creek, 2; South Fork Pit River near Alturas, 3; Warner Mts. (Parker Creek and Squaw Peak), 6. Siskiyou County: near head of Little Shasta River, north of Goose Nest Mt., 1; Bull Meadow, northeast of Goose Nest Mt., 1; seven miles south of Macdoel, 24; Grass Lake, 6. Lassen County: Termo, 1; west end of Horse Lake, 1; fifteen miles west of Westwood, 1. Plumas County: ten miles west of Big Meadows, 1.

The Oregon Ground Squirrel occurs in California only in the extreme northeastern counties of the state; but it has a rather wide general range which includes much of Oregon east of the Cascades, and parts of northern Nevada. It is a Great Basin plateau species, and its range ends to the westward in California rather abruptly in the vicinity of Goose Nest Mountain (head of Little Shasta River and Grass Lake) and in the Pit River Valley in the vicinity of Burney, Shasta County. To the southward it extends to Big Meadows, in Plumas County a little southeast of Mount Lassen, and to the valley of Susan River, in Lassen County.

In most of the sagebrush territory thus bounded, the Oregon Ground Squirrel is conspicuously abundant, more so, some people believe, than any other species anywhere in this state. While not so large as the

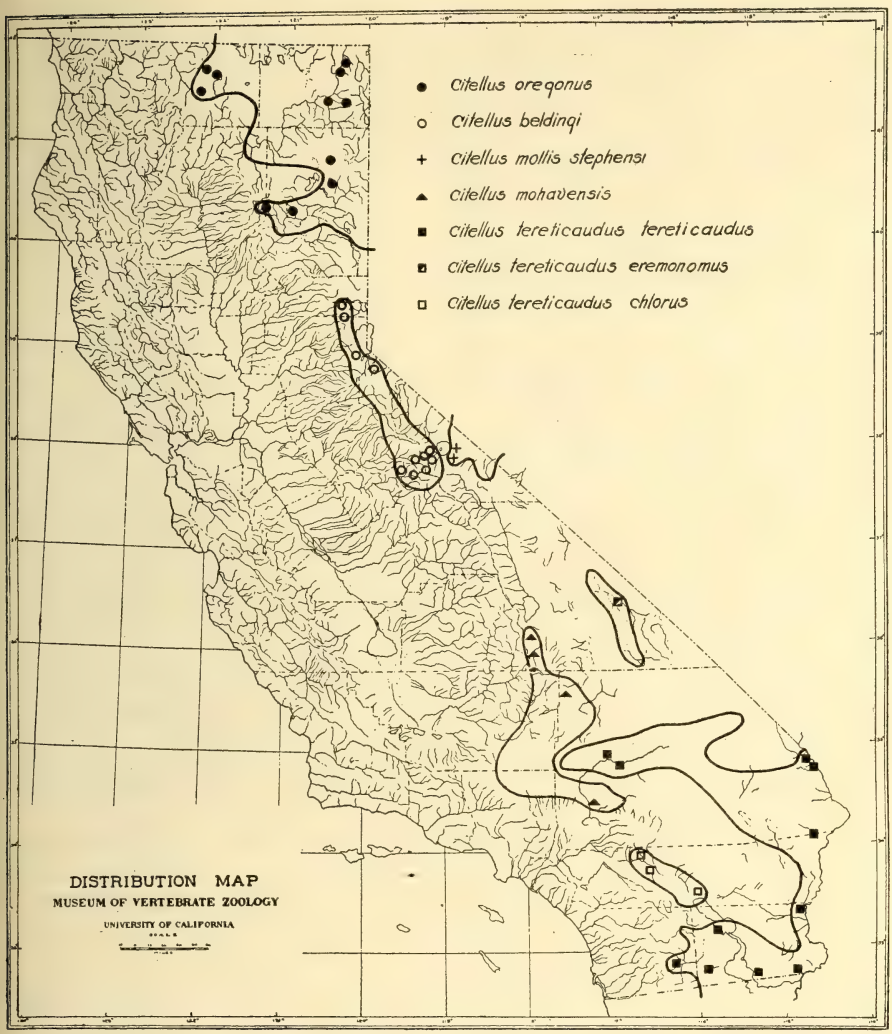


FIG. 18. Map showing California distribution of the Oregon, Belding, Stephens Soft-haired, Mohave, Yuma Round-tailed, Death Valley Round-tailed and Palm Springs Round-tailed ground squirrels. The spots represent localities from which actual specimens have been examined.

Beechey Ground Squirrel individually, it exceeds that species in numbers. At any rate, it ranks highest in importance among rodent pests within its domain.

The Oregon Ground Squirrel is an inhabitant chiefly of mountain meadows and the borders of the bigger meadows of the valleys. It does not care for marshy ground, and it avoids thick brush and rocky slopes. In a way, it is complementary in habitat to the Douglas Ground Squirrel, which occurs in much of the same territory; rarely are the two seen on common ground. It is obviously because of its preference for grass land that the Oregon Ground Squirrel has come so seriously

into conflict with man's interests. Extensive clearing of the sagebrush and seeding of these clearings to grain and hay has doubtless benefited the squirrels. Indeed, this is likely one of the factors that accounts for their increase of late years as testified to by several of the old-time residents whom we have interviewed.

In Butte Valley, Siskiyou County, the Oregon Ground Squirrels are popularly known as "bull dogs," in Modoc County as "short-tails" (evidently as distinguished from the longer tailed Douglas Ground Squirrel), and elsewhere, locally, as "bobbies," "prairie dogs," "gophers," and "woodchucks." The last three names, of course, are misapplications of names properly belonging to quite different kinds of rodents.

In the latter part of May, 1918, the senior author accompanied Mr. W. C. Jacobsen, State Superintendent of Rodent Control, in a tour through northeastern California for the particular purpose of studying the Oregon Ground Squirrel. In traveling eastward from Shasta Valley, we first encountered this species toward the head of the Little Shasta River, on the Mills ranch at about 4,200 feet altitude. Here we found a field of vetch to be riddled with the burrows and secured one of the animals to verify this, the westernmost record station for the species. At Bull Meadows, a little east of Goose Nest Mountain, the squirrels were exceedingly numerous on the uncultivated open ground among scattering lodgepole pines. Subsequently we found them plentiful around the margins of Grass Lake, nearly as far west, but due south of Goose Nest. But it was on the floor of Butte Valley, from the vicinity of Bray north to Dorris, wherever there were open grass lands, that the Oregon Ground Squirrels simply swarmed. The following observations made May 16, 1918, on a ranch seven miles south of Macdoel, will give an idea of the abundance of the animals where conditions are most favorable to them.

Taking a position at the right-angled intersection of two fences, the observer counted the animals in the quarter-circle gaze thus bounded and found that there were sixty-five squirrels in plain sight within a distance of one hundred yards of him. This was about nine o'clock in the forenoon of a bright day, when the squirrels were at about the height of their daily activity aboveground. Young of the year were included.

Again, three adjacent plots of pasture were paced off, thirty-nine paces square, and the open burrows counted. In one plot there were 151, in the second 182, in the third 194, an average of 176. This, figured out, makes 560 open burrows to the acre! If we allot one adult squirrel to each five openings, which our observations showed to be about the proper ratio, there would be 112 adults to the acre, not counting young. Figuring, further, this would make somewhat over 70,000 squirrels per square mile! This, however, would pertain only in limited areas and to those pasture lands where little effort had yet been made to reduce the pests. The population of the sagebrush plains and pine woods of Butte Valley would be much smaller. It is, of course, the pasture lands and grainfields where the squirrels come into chief conflict with man's interests, and this is where they are most abundant. Some further estimates in this connection are likely to prove worth while.

The average weight of six adult female Oregon Ground Squirrels was found to be 302 grams (about 10½ ounces). The full stomachs of these six squirrels were found to give an average weight of 18.5 grams. Subtracting the ascertained weight of the stomach itself (3.5 grams), gives the weight of the contents, alone, representing doubtless one full meal, as 15 grams, or one-twentieth the entire weight of the animal. The stomach contents was in all cases a closely packed, slightly moist (not watery) mass of finely chewed green stuff. This could not be analyzed as to kinds of plants represented, but the squirrels were seen to be feeding upon all sorts of vegetation, practically everything going to make up the usual forage grazed from such lands by live stock.

Our observations led us to believe that, at the very least, two full stomach-loads of greens were eaten by each squirrel each day, or 30 grams of forage. Of course this does not account for wastage, evidence of which, in the way of cut stems and grass blades, was plentiful. Figuring from the average number of adult squirrels per square mile, 70,000, and counting on two meals per day, we find a minimum of 2,100,000 grams, or somewhat more than two tons, of green forage devoured by the squirrels each day on a square mile of pasture. Granted that a grazing steer eats fifty pounds of pasture forage each day, we conclude that the squirrels on a square mile of pasture appropriate each day the forage which might support ninety head of cattle.

Expressing it in other ways, 750 Oregon Ground Squirrels during the growing season of pasture grass eat as much as one steer, and the squirrels on every seven acres of pasture thickly inhabited by them eat as much as one steer!

The burrows of the Oregon Ground Squirrel where the animals are at all numerous fairly riddle the ground. Most of the openings come to the surface at a rather steep angle and without any earth at their mouths. Now and then there is an opening which slants to the surface and has a good-sized mound, and such as these seem to mark the nesting burrows as distinguished from the short, temporary, refuge burrows, or those occupied by males. We spent the entire day of May 16 excavating one nesting burrow, with results shown in figure 19.

The mound at the main entrance to this burrow system was rather large in extent, though shallow. It consisted of this year's loosely piled earth, covering up the grass on an area of nearly two square yards and thus marking the place conspicuously. The system of burrows, in part at least, probably represented two seasons' work and maybe more. While there were only two openings to this system, there were several points at which underground branches came nearly to the surface so that a hard-pressed squirrel, pursued by some underground enemy, could have quickly dug clear out and escaped overland.

As usual with ground squirrels, the runways were everywhere smooth and free from excrement, the nest chamber in use being unexpectedly clean. The feces of the young are evidently collected by the mother and carried to the places where her own are deposited, in the special branches or defecatoria. Here the earth is tamped over the mass in such a way that the pellets are kept separated by the soil particles, with no chance to fester. The fecal pellets are dryish, anyway. Some saved for examination, probably from the adult squirrel, prove to be

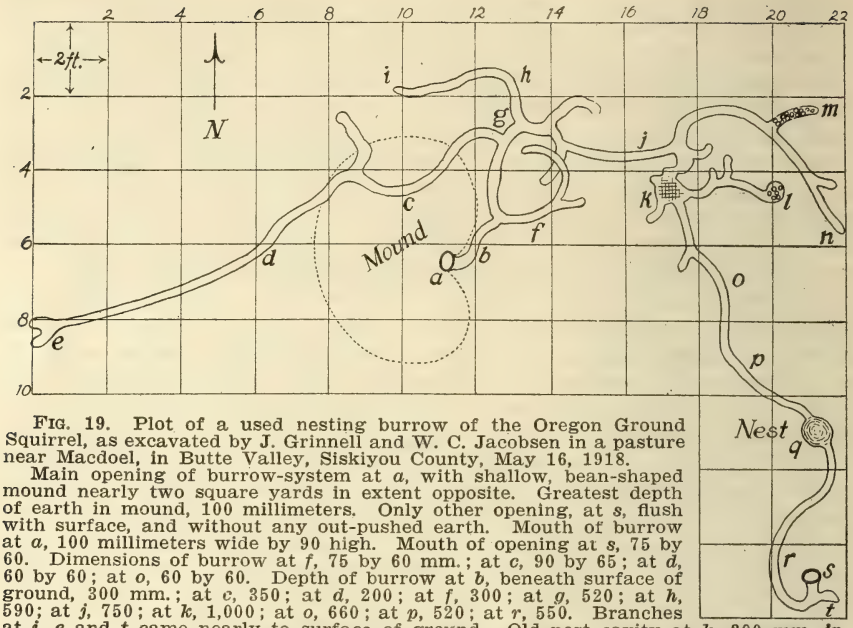


FIG. 19. Plot of a used nesting burrow of the Oregon Ground Squirrel, as excavated by J. Grinnell and W. C. Jacobsen in a pasture near Macdoel, in Butte Valley, Siskiyou County, May 16, 1918.

Main opening of burrow-system at *a*, with shallow, bean-shaped mound nearly two square yards in extent opposite. Greatest depth of earth in mound, 100 millimeters. Only other opening, at *s*, flush with surface, and without any out-pushed earth. Mouth of burrow at *a*, 100 millimeters wide by 90 high. Mouth of opening at *s*, 75 by 60. Dimensions of burrow at *f*, 75 by 60 mm.; at *c*, 90 by 65; at *d*, 60 by 60; at *o*, 60 by 60. Depth of burrow at *b*, beneath surface of ground, 300 mm.; at *c*, 350; at *d*, 200; at *f*, 300; at *g*, 520; at *h*, 590; at *j*, 750; at *k*, 1,000; at *o*, 660; at *p*, 520; at *r*, 550. Branches at *i*, *e* and *t* came nearly to surface of ground. Old nest cavity at *k*, 300 mm. in diameter, and floored with a damp mixed mass of old frazzled grasses, excrement, and earth. At *m* and *l*, chambers, 770 and 1,110 mm., respectively, beneath surface of ground, packed full of a mixture of excremental pellets and loose earth. Blind terminal at *n*, 850 mm. deep. New nest, in use, containing many live fleas, at *q*; cavity of this, 190 mm. wide by 170 high, and 700 mm. beneath surface of ground, nearly filled with a dry clean hollow mass of shredded juniper bark and weathered grasses. The excavating was begun at *a*, and the female and six third-grown young were overtaken at *s* and *t*, where they were about to escape.

Total length of this burrow system, 66 feet. Average diameter of burrow, 2½ inches. Volumetric content of entire system, 3½ cubic feet. Greatest depth reached, 45 inches, or nearly 4 feet.

short-cylindrical or elliptical in shape, and measure 6.5 millimeters in diameter by from 15 to 22 in length.

There were two nest cavities in the system unearthed, an old one, and the one in use. The latter contained a dry, hollow mass of frazzled juniper bark and weathered stems and blades of grass. The female parent and six third-grown young were overtaken farther along in the burrow system, near one terminus of it, but that the nest had but recently been vacated was shown by its feeling of warmth to the touch and the presence of numerous lively fleas. The female proved a tartar in defense of herself and young, biting effectively with her sharp incisor teeth and scratching with her strong claws. This was as a final recourse, however, as the first endeavor on the part of all the occupants, when the burrow was opened up, was to escape and run to the nearest shelter, such as offered by some neighboring burrow, or by a flat rock. As far as our observations went, there was no indication that the adult male lives in the same burrow with the female, or has, indeed, anything to do with the rearing of the young.

The burrow system in question was found to be 66 feet long, including the various windings and all of its branches. Its average diameter was about 2½ inches, and the volume, or cubical air content, 3½ cubic

feet. The greatest depth reached beneath the surface of the ground was 45 inches. This was in rather dry pasture, and there was no sign of a water-table; the soil to this depth was only moderately damp.

The notes of the Oregon Ground Squirrel are of two sorts. The most impressive consists of a series of from 8 to 12 shrill, high-pitched calls, uttered in rapid succession—*seep, seep, seep, seep, seep, seep, seep, seep, seep.* The tendency is to weaken on the last few syllables, but the same pitch is nearly or quite maintained throughout. This call seems to be uttered only by adults, and seems to signify alarm at the first, or distant, approach of danger. One hears it taken up here and there all over a large meadow when it is first entered. Then there is a single shrill chirp of somewhat lower pitch, uttered now and then by either old or young. At times one will hear scarcely a note for many minutes, even when many of the squirrels are in sight, and then again the calls will be given back and forth from all sides.

One old female watched from a distance of 20 feet stood stock still for several minutes at the mouth of her burrow, in upright, "picket-pin" fashion. The fore feet she held against her stomach in front. When she gave the several syllabled call she opened her mouth very wide, depressing the tongue on to the floor of her mouth so that it could not be seen, and uttered the successive notes with much appearance of effort. The convulsive movements of the body were synchronous with the notes as uttered. The picket-pin attitude is really not so frequent as a crouching one, though when it *is* assumed it renders the squirrel visible a long way, especially where the grass is short. When feeding, the squirrel hunches over on its haunches, and uses both front feet and the fingers of these for holding and manipulating the food. When foraging the squirrels do much slinking along, with body horizontal and seemingly touching the ground. When a general alarm is sounded one sees them running in every direction, with a rather clumsy and not rapid, hopping gait. When so running the tail, short and never conspicuous, is held either out straight behind or raised at an angle of 30 degrees. Often when halting, or coming to a stand on the alert, the tail is twitched up from the horizontal several times in rapid succession, the whole body also twitching at the same time.

Rarely does an Oregon Ground Squirrel leave the ground, even to climb onto a rock or log. The body is relatively heavy and the general movements are far from nimble. In just one instance was a squirrel observed to have actually climbed; one individual was seen at Sugar Hill, Modoc County, up in a bush four feet above the ground (W. P. Taylor, MS). Marshes or very wet meadows are avoided; in other words, this species does not take to water. Still, we have the one instance of an individual, near Canby, Modoc County, seen (W. C. Jacobsen, MS) swimming across the Pit River. The current here was sluggish and the channel about eighteen feet wide. The act was to all appearances voluntary.

At the season of our special observations, the middle of May, the Oregon Ground Squirrels were seen to be feeding on practically every sort of pasture vegetation. Cuttings of meadow grass, blades and stems of grain, and leaves and stems of alfalfa were seen on their mounds or in the mouths of their burrows. As already stated, determination of



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the kinds of plants eaten, from stomach examination, proved impracticable because the food is chewed so finely. Even young less than a third grown were feeding freely on green stuff. Six young taken on May 16 were found to weigh from 65.1 to 104.7 grams, averaging 82.4 grams as compared with 302 grams, the average weight of adults. Their stomachs were distended with finely cut food, and were found to weigh on an average 5.4 grams, or about one-fifteenth their total weight as against the one-to-twenty ratio in adults. It would seem that partly grown young eat more in proportion to their size than old squirrels—which was rather to be expected.

There seem to be two periods of maximum daily activity aboveground on clear days, about 9 a.m. and again in mid-afternoon. This squirrel seems to be preëminently a sunshine forager. One day when a thunderstorm came up in the afternoon the squirrels nearly all disappeared from aboveground coincidently with the gathering of the clouds.

The breeding season of the Oregon Ground Squirrel, as is to be expected, varies with altitude, or, rather, with life-zone. The young are born later in the Transition and Boreal zones, than in the Upper Sonoran. On May 15 scores of adults were seen on Bull Meadows, near Goose Nest Mountain, 5,000 feet altitude, in the Canadian zone, but not one youngster was seen; while on May 16 everywhere in Butte Valley around Macdoel, at 3,000 feet, in the Upper Sonoran zone, young were out in great numbers. All of these were of about the same size, one-fourth to one-third grown, showing the uniformity of time of birth throughout a region of uniform temperature conditions. On May 19, 1910, a collecting party from the California Museum of Vertebrate Zoology found small young, just out, on Sugar Hill, 5,000 feet altitude, Modoc County.

There is but one litter a year, and the number to a litter is supposed to vary from 4 to 15, averaging about 8. Exact statistics from which to determine these figures accurately are not available. A man who was irrigating an alfalfa field near Macdoel regularly day after day told us that he had drowned out many families of young and that the broods he had seen consisted of from 4 to 11, averaging, he thought, 8. Mr. W. C. Jacobsen, from his own extensive experience with this species, considers 4 and 12 to be extremes, and 8 the average. He knows, indirectly, of one case of 15.

The Oregon Ground Squirrels lie dormant in a dry nest beneath the surface of the ground for fully half the year, even at the lowest altitudes in the general territory inhabited by them. The bulk of the population goes into hibernation during July and does not come out until March. These statements are made upon the authority of Mr. W. C. Jacobsen, who is further of the opinion that the exact time of disappearance, which varies somewhat from year to year, is controlled by moisture and consequent supply of green food. The drier the year the earlier the squirrels go into winter quarters, this in spite of the hotter late-summer temperature at the lower altitudes. In 1915, the squirrels in Big Valley, Lassen County, had nearly all gone in by July 3; in Warm Springs Valley, Modoc County, they had gone in by July 10; but on the Warner Mountains, Modoc County, they were just going in on July 22 of the same year. In 1914, a year of more moisture and better feed, the time of

SIERRA GOLDEN-MANTLED GROUND SQUIRREL (AT LEFT). BELDING GROUND SQUIRREL (AT RIGHT).

beginning hibernation at the same points was one and one-half to two weeks later. Individuals have been reported to us as seen aboveground as late as the first week of September, but all reports agree that the majority are "holed up" before the first week in August.

In the spring the animals reappear often when there is yet much snow on the ground. In 1916 they were out in force on March 16, when they had burrowed up in places through two feet of snow and were nibbling the sagebrush tips (W. C. Jacobsen, MS).

Enemies of the Oregon Ground Squirrel were, under original conditions, doubtless numerous and effective in keeping down its numbers. Gopher snakes, rattlesnakes, badgers, coyotes and Swainson Hawks are known to feed regularly on it. Mr. J. O. Miller, a professional trapper living at Yreka, informs us that nine out of ten coyotes trapped by him during the summer months have remains of ground squirrels in their stomachs. One coyote taken in Butte Valley had parts of seven Oregon Ground Squirrels in its stomach. An old-time resident near Alturas told the senior author that the killing off of the "varmints" (predaceous animals) in recent years seemed to him to have had something to do with the increase and spread of ground squirrels. We are strongly inclined to his belief. Encouragement of those natural enemies which are not in themselves seriously detrimental to man's interests would go far to check the undue increase of the ground squirrels.

## BELDING GROUND SQUIRREL.

### Citellus beldingi (Merriam).

PLATE III.

**Other names.**—Belding Spermophile; Bob-tailed Spermophile; Prairie Dog, part; Picket-pin, part; *Spermophilus elegans*; *Spermophilus beldingi*; *Colobotis beldingi*.

**Field characters.**—A medium-sized, short-tailed, "picket-pin" type of ground squirrel, without side-stripes or other conspicuous markings, but with bright reddish brown back. Length of body alone about 7⅘ inches, with tail 2⅔ inches more. (Closely similar to Oregon Ground Squirrel, but smaller and with back reddish brown instead of brownish gray; compare figs. 20a and 20b.)

**Description.**—Adult in full fall pelage: Sides of head, hind neck, shoulders, sides of body and flanks continuously yellowish brown (numerous fine hairs which are chiefly black, though light-tipped, lend a dusky tone to these areas); a tinge of olive-ochre pervades the lower margins of those areas adjoining the light underparts; eyelids white; whiskers black; ears dusky, finely haired, not tufted; crown of head to nose, tawny-olive; a broad sharply outlined band of bright hazel brown running down middle of back from between shoulders, narrowing to base of tail. Tail short, full-haired, flattish; above mixed hazel and black, black predominating toward end, where also a well-defined buffy white fringe; under surface of tail conspicuously deep cinnamon-rufous, with subterminal black interval, and buffy white fringe all around. Upper sides of feet buffy white; claws chiefly black, with horn-colored tips; palms naked; soles naked save for sparse hairing from heel halfway to tubercles. Under side of head and neck, and inner sides of fore and hind legs, buffy white; belly cream-color, with lead-color of bases of hairs showing through.

**Color variations.**—As far as we can see from the series of specimens studied, adults molt but once a year, during July. May and June specimens show clearly the effects of wear and fading, and are grayer, with the mid-dorsal brown area much duller than in the fresh pelage described above. Young not one-fourth grown are like adults in color, but with mid-dorsal area paler, snuff brown, and under side of tail clay color.

**Measurements.**—Average and extreme measurements, in millimeters, of twenty mature specimens from the Yosemite section of the high Sierra Nevada are as follows: Ten males: total length, 263 (230–280); tail vertebræ, 66 (60–74); hind foot, 44 (41–45.5); ear from crown, 9 (7–11); greatest length of skull, 44.5 (42.2–46.3); zygomatic breadth, 28.0 (26.4–29.5); interorbital width, 10.5 (9.7–11.0). Ten females: total length, 260 (240–288); tail vertebræ, 66 (55–74); hind foot, 43 (40–46); ear from crown, 10 (8–13); greatest length of skull, 44.0 (41.3–46.5); zygomatic breadth, 28.2 (26.7–28.9); interorbital width, 10.4 (9.7–11.0).

Relatively old individuals show greatest size, especially of skull, which also has acquired more conspicuous ridges and sharper angles. Males average a trifle larger than females.

**Weights.**—Average and extreme weights, in grams, of twenty mature specimens from the Yosemite section of the high Sierra Nevada are as follows: Ten males, 222 (125.5–285.0); ten females, 240 (172–305). Average, in ounces, both sexes, about 8.

The example showing the least weight was fully adult, but was very lean. Like other ground squirrels this species varies greatly in weight according to the amount of fat present. Specimens taken in August and September are, as a rule, fattest.

**Type locality.**—Donner, Placer County, California (Merriam, 1888, pp. 317–320).

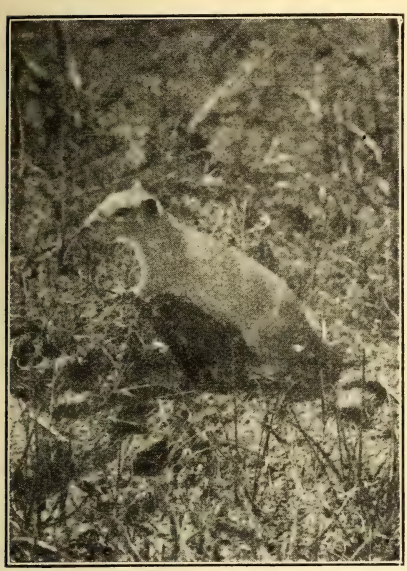
**Distribution area.**—Higher parts of the central Sierra Nevada (chiefly Hudsonian life-zone), from vicinity of Independence Lake, Nevada County, south to southeastern border of Yosemite National Park in vicinity of Mount Lyell (see fig. 18). Altitudinal range, from 11,800 feet (as on Mt. Conness) down on western flank of Sierras to as low as 8,100 feet (Porcupine Flat, Yosemite Park); on eastern flank to as low as 6,500 feet, at western border of Mono Lake (Mus. Vert. Zool.).

**Specimens examined.**—A total of 48 from the following localities in California: Nevada County: Independence Lake, 13. Placer County: "Johnson's Pass, High Sierras" [= Summit], 1. El Dorado County: Mt. Tallac, 1. Alpine County: Hope Valley, 4. Mono County: Mono Lake P. O., 1; Farrington's, Mono Lake, 3; Mono Pass, 1; Tioga Pass, 1; Walker Lake, 1. Tuolumne County: Tuolumne Meadows, 8; middle Lyell Canyon, 1; head Lyell Canyon, 5. Mariposa County: Mt. Hoffman, 10,700 ft., 1; Tioga Road, southeast Mt. Hoffman, 3; near Vogelsang Lake, 2; two miles east Porcupine Flat, 1; one mile east Lake Merced, 1.

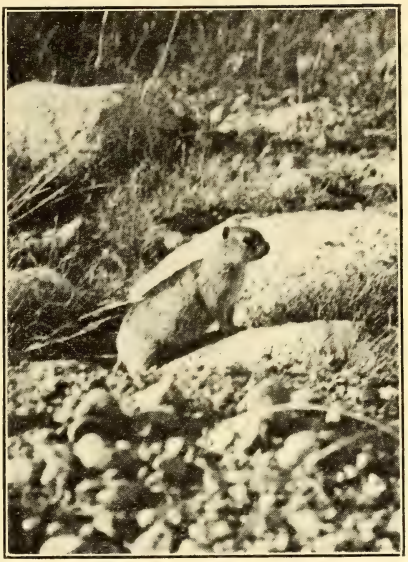
This species of ground squirrel was named after Lyman Belding, an early resident of Stockton and a naturalist of considerable attainment. Belding found it in the summer of 1885 in the vicinity of Summit, Placer County, and sent a specimen to Dr. C. Hart Merriam, who later (1888) described the species, calling it *Spermophilus beldingi*.

The most notable thing about the Belding Ground Squirrel is the great altitude of most of the area it inhabits. It is very closely restricted to the alpine meadows of the high central Sierra Nevada. The warmer levels below seem to be just as inimical to *its* welfare as the cold upper zones certainly are to the other ground squirrels which inhabit the middle slopes or foothills. Reference to our diagram (fig. 23) will show some interesting facts in this regard. We would infer that the Belding Ground Squirrel is the hardiest of all our species as regards ability to endure long and cold winters, though here the habit of hibernation must come importantly into play as tiding it over the extremes.

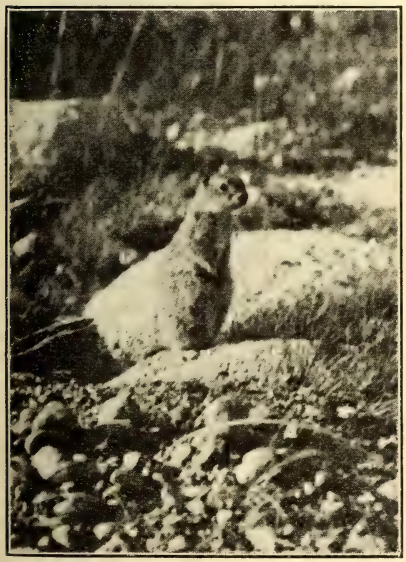
This squirrel occurs in fair abundance on the preferred portions of its general range, namely, the grassy meadows in the neighborhood of timber line. Individuals rarely occur down as low as the belt of red firs and aspens (Canadian zone) on the west slope of the Sierras, though on the east slope a few do occur down through the Jeffrey pine belt. It is quite strictly an inhabitant of open levels; it is rarely or never seen in the woods or on steep or rocky slopes. Occasionally an individual ascends to the top of some glacier-borne boulder out in a meadow for a look around, but we have yet to observe any greater exploit in climbing.



(a) Oregon Ground Squirrel in meadow near Klamath Falls, Oregon. Photographed by H. C. Bryant, May 30, 1914. Note uniform coloration with no indication of a reddish brown patch on back.



(b) Female Belding Ground Squirrel at entrance to burrow; Tuolumne Meadows, Yosemite National Park. Photographed by T. I. Storer, July 27, 1915. Note patch on back rendered photographically nearly black, but which was reddish brown. Compare with *a*.



(c) Same squirrel as shown in *b* standing upright in characteristic "picket-pin" attitude.

(d) Sierra Golden-mantled Ground Squirrel or "bummer," feeding on scraps from the camp table. Note the distended cheek. Bullfrog Lake, 10,600 feet, Fresno County. Photographed by J. Dixon, September 1, 1916.

FIG. 20.

Probably because of the open nature of their forage ground, these squirrels seem exceptionally timid. The shrill cries of alarm greeting the invader of a meadow upon his approach are quickly followed by total disappearance of the animals, at least for the time being. Each individual seems not to wander usually more than a few yards from the mouth of its burrow, so that but a short run intervenes at any moment between it and safety. The tail is held down when running, not elevated nor waved. The gait is rather slow and clumsy, impressing one observer as resembling that of a short-legged dog. "Where the grass is short there is little up-and-down movement of the body shown in running; but in high grass, instead of parting the stalks and pressing them aside as it progresses, the animal advances by a series of jumps each of which carries it up clear of the grass so that it can glimpse about for a possible enemy" (T. I. Storer, MS).

When within but a few feet of the mouth of its burrow and first taking alarm, a squirrel will rise quickly on its haunches and assume the rigid, upright, "picket-pin" posture (see fig. 20c). This usually brings the animal's head well above the grass tops, so that it can get a good view all about. Also it can then be seen a long way, looking in the distance like a tent-stake or picket-pin out on the meadow. During this pose the fore limbs are pressed closely against the body. Sometimes the animal rises still higher, supporting its whole body on its hind feet and using its stubby tail as a prop (C. L. Camp, MS). The fact that the nose is continually twitched up and down, as if the animal were drawing in air, suggests that the sense of smell may be keen and that it may be used to determine the nature of a supposed enemy. If the observer continues his approach the squirrel suddenly deserts its "picket-pin" pose and dashes for its burrow, where it may hesitate a moment on all fours for one final look before diving out of sight.

The voice of this squirrel closely resembles that of the Oregon Ground Squirrel. The usual call of warning consists of a series of from five to eight short shrill whistles uttered in quick succession and weakening toward the last. Females warn their young when foraging abroad with a lower-pitched, double note, or bark, *e-chert'*. A single note, *sirt,* is also frequently heard.

The burrows of the Belding Ground Squirrel are generally located in the meadows which form their forage grounds. Sometimes, near timber line, one finds them in the scant gravelly soil between granite boulders, but always in or near patches of the kind of bunch grass occurring at such altitudes. The mounds are rarely conspicuous, and the holes open up to the surface steeply. Often there is no surplus earth at all around the mouths of the burrows, but this condition might be accounted for by the effects of washing from heavy rain or melting snow. Several measurements of burrows gave an average diameter of two inches. The extent of the underground burrow system has only been tested out in one instance (see fig. 21). In this case the burrow was located in a wet meadow, snowbanks melting all about at the time (June 28), and it proved to be shallow, reaching an extreme depth of only about thirteen inches. But blind branches directed downward indicated the probability of greater depth later in the season when the water table had lowered and the soil dried out. The total length of this burrow system, including all its branches, was close to 54 feet.

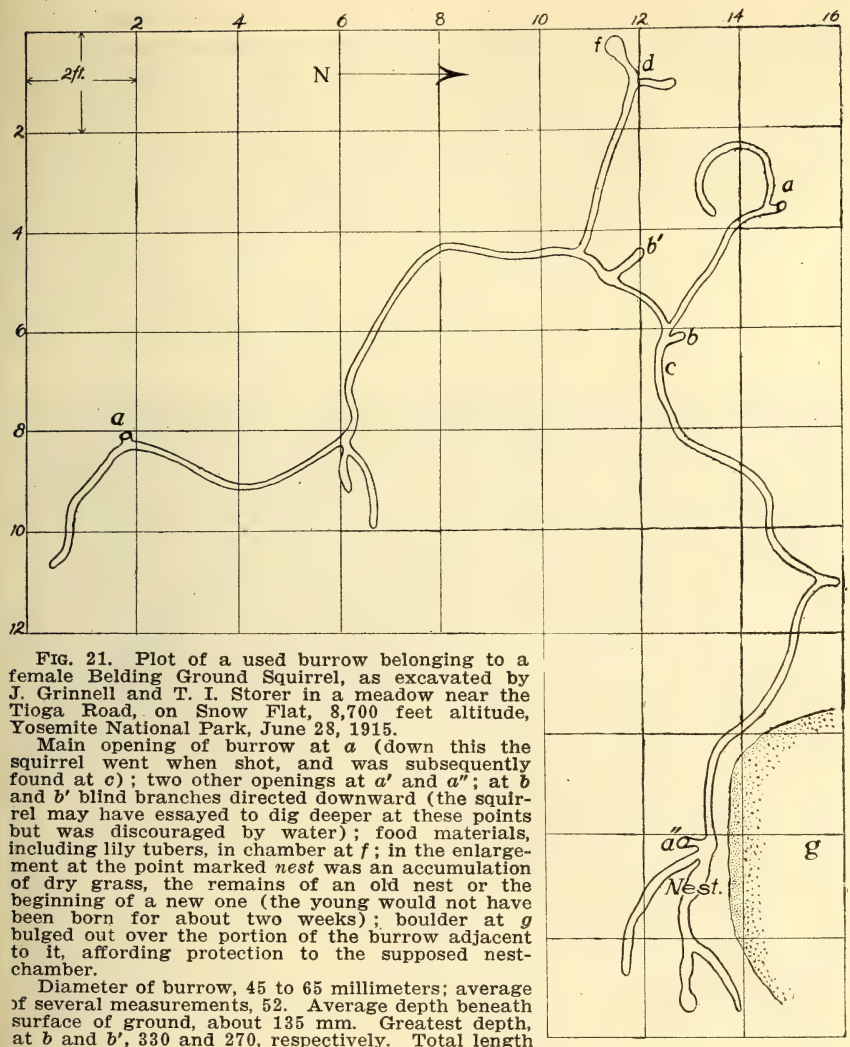



FIG. 21. Plot of a used burrow belonging to a female Belding Ground Squirrel, as excavated by J. Grinnell and T. I. Storer in a meadow near the Tioga Road, on Snow Flat, 8,700 feet altitude, Yosemite National Park, June 28, 1915.

Main opening of burrow at *a* (down this the squirrel went when shot, and was subsequently found at *c*); two other openings at *a'* and *a''*; at *b* and *b'* blind branches directed downward (the squirrel may have essayed to dig deeper at these points but was discouraged by water); food materials, including lily tubers, in chamber at *f*; in the enlargement at the point marked *nest* was an accumulation of dry grass, the remains of an old nest or the beginning of a new one (the young would not have been born for about two weeks); boulder at *g* bulged out over the portion of the burrow adjacent to it, affording protection to the supposed nest-chamber.

Diameter of burrow, 45 to 65 millimeters; average of several measurements, 52. Average depth beneath surface of ground, about 135 mm. Greatest depth, at *b* and *b'*, 330 and 270, respectively. Total length of system, about 54 feet.

The burrow system above described belonged to just one squirrel, an adult female, which was found to contain five embryos, the only exact evidence we have as to the number of young to a litter. This was at 8,700 feet altitude, on Snow Flat, Yosemite Park, on June 28. Half-grown young were common on Tuolumne Meadows, 8,600 feet, July 16. Young two-thirds grown have been taken at Independence Lake, Nevada County, 7,000 feet altitude, as early as July 13. Three third-grown young were seen, and one of them photographed (fig. 22), at 6,800 feet altitude near Williams Butte, Mono County, June 28. There is thus probably some variation in time of appearance of the young, with altitude, the animals at the highest levels being born latest in the season. The young are out quite generally by the 15th of July. Only one litter

is born each year. On July 31, on Tuolumne Meadows, Yosemite Park, young Picket-pins were out in parties of six mostly, and sat about the mouths of their burrows or foraged in the very near vicinity. When frightened all members of each group darted for their refuge at the same time, crowding into the hole with some difficulty.

Belding Ground Squirrels become very fat in late summer and hibernate regularly; but exact dates of beginning hibernation in the autumn and emerging in the spring are wanting. We do know that they are not averse to running about over the surface of the snow at high altitudes in June, and so probably come out much earlier, and that in one year, 1915, they were still out as late as October 7 in the vicinity of Ten Lakes, Yosemite Park, although a light snowfall had already occurred. They were numerous on the extensive meadows in Tioga

FIG. 22. Third-grown young Belding Ground Squirrel; photographed by J. Dixon, June 28, 1916, near Williams Butte, Mono County.

Pass on September 28. It is evident that, in spite of its more elevated habitat, the Belding Ground Squirrel goes into its winter sleep a full two months later than the Oregon Ground Squirrel.

Like the Oregon Ground Squirrel, the Belding feeds largely on grass stems and blades. An individual has been seen gathering seeds from grass heads, pulling the latter down to its mouth with its fore feet; but it is certainly not the seed-eater that the California and Golden-mantled ground squirrels are. Neither is there evidence that the Belding stores up much food. As with the Oregon species, its cheek-pouches are small (see fig. 13b). At Soda Springs, on Tuolumne Meadows, the Belding Squirrels have been seen foraging like rats about the mule corral.

The enemies of this species of squirrel probably include most of the carnivores of the high mountains. A Mountain Weasel (*Mustela arizonensis*) has been seen to kill one by biting it through the back of the neck (C. L. Camp, MS).

The Belding Ground Squirrel bears no decided economic importance, save as might be involved in the grass it eats. Its habitat falls only within the summer range of sheep and cattle, and its numbers are nowhere so great as to be likely to reduce the crop of pasture grass to any material extent.

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## STEPHENS SOFT-HAIRED GROUND SQUIRREL.

### Citellus mollis stephensi (Merriam).

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**Other names.**—Stephens Spermophile; Picket-pin, part; Stephens Ground Squirrel; *Spermophilus mollis stephensi.*

**Field characters.**—Small size combined with very short and slender tail and gray coloration (no stripes or special markings); ear small; length of body alone about 6¼ inches, with tail about 2 inches more.

**Description.**—Nearly full-grown young in summer pelage (June): General tone of coloration on upper surface of body, buffy gray; top of head from nose to hind neck, pale cinnamon-buff, deepest on nose, and changing into color of back on shoulder; cheek to shoulder, olive-buff; eyelids white; whiskers black; back light drab with a faint effect of fine dappling; the hairs on the back lead-colored at extreme bases, then gray, then bister, and tipped with buffy white. Upper surfaces of feet dull white; palms naked; soles of hind feet clothed with dull whitish hairs to about halfway forward from heel; claws blackish, with horn-colored tips. Tail flat-haired, but narrowly so, and tapering from base to tip; upper surface buffy drab; beneath dull white at base, becoming dusky pinkish buff toward end. Lower surface of body silvery white, faintly buff tinged, particularly as forming a band along each side, and with much of the leaden-hued bases of the hairs showing through.

We have at hand but two specimens of this ground squirrel, and these are both immature.

**Color variations.**—A considerable series of specimens of *Citellus mollis* (subspecies?) at hand from northern Nevada make it seem likely that *stephensi* varies in color but little from the coloration as here described; probably old adults are grayer, with little or none of the cinnamon-buff about the head. The summer pelage at all ages is notably soft and silky as compared with that of most other species of ground squirrels at the same season. There is possibly a distinct winter pelage, with regular molts in spring and fall; but we have no specimens to indicate this.

One of our two specimens has the tail much flatter, and broader ended, than the other; but this we think is due to the way the tail was wired when the skin was prepared. The usual thing is for the tail to taper from base to tip, thus quite unlike the condition found in the Mohave Ground Squirrel.

**Measurements.**—Nine specimens from the head of Owens Valley, in California, average, in millimeters as follows: total length, 212; tail vertebræ, 50; hind foot, 32.4 (Merriam, 1898, p. 70).

The two immature specimens in the Museum of Vertebrate Zoology, from near Mono Lake, measure as follows, the first figures given being for the male, the second for the female: total length, 195, 185; tail vertebræ, 45, 45; hind foot, 32, 32; ear from crown, 4, 4; greatest length of skull, . . ., 35.6; zygomatic breadth, 21.8, 22.0; interorbital width, 7.4, . . . .

**Weights.**—Our two specimens weigh, in grams, as follows: male, 83.6; female, 78.0 (in ounces, about 3 and 2¾, respectively).

**Type locality.**—Queen Station, near head of Owens Valley, Nevada [in Esmeralda County, just across California boundary] (Merriam, 1898, p. 69).

**Distribution.**—Within the state of California, in only a very limited area comprising the sagebrush valleys of eastern Mono County, namely from southeastern edge of Mono Lake to head of Owens Valley in vicinity of Benton Station (see fig. 18). Life-zone, Upper Sonoran chiefly, barely entering Transition locally (see fig. 23). Southernmost known locality of occurrence, Taylor Ranch, in Owens Valley, two miles south of Benton Station. Altitudinal range, 5,300 to 7,300 feet.

**Specimens examined.**—A total of 2, both from Mono County: Mono Mills, 1; Dry Creek, 1.

The Soft-haired Ground Squirrels belong to the Great Basin region of the western United States and get into our California list only on the basis of the occurrence of one of the subspecies, the Stephens, in a few places along the eastern border of the state. This is a distinctly different type of ground squirrel from any of our others, notably in the soft, silky "feel" of the hair. In addition, the small size, short slender tail, and uniform light grayish coloration make a combination of characters which is unique among our species.

Unfortunately, our own personal experience with this species has been very limited. In September of 1917 the two of us made especial search for it at the extreme head of Owens Valley. But we were too late in the season; locally well known in the vicinity of Benton, we were assured by the ranchers that the animals had all "holed up" by about the end of July. On the Pellisier Ranch, five miles north of Benton Station, "Picket-pins" were declared to have been present "by the million" from April until July, but it was averred that by the last of August they had all disappeared. Numerous round holes in the ground among the sage bushes were pointed out to us as belonging to these squirrels. There was abundant evidence that coyotes and badgers regularly dig them out. Also we were told that at the season the squirrels are above ground the Indians capture many for food.

On the Taylor ranch this squirrel was reported to be plentiful, but to vary much in numbers from year to year. In the spring of 1916 it was abundant; in 1917 scarcely any were seen.

In the sand-dune area along the east side of Mono Lake, the junior author saw several Soft-haired Ground Squirrels on June 10, 1916. The sand was fairly covered with their tracks. Those individuals seen on June 11 near Dry Creek in the same neighborhood were notably tame. They gave the impression of being flat-bodied, and slid along the ground like lizards, stopping to scrutinize the intruder from the shelter of the first bush reached. One was captured under a bush by being pinned down with the gun.

Mr. Frank Stephens of San Diego, for whom this subspecies was named, states (1906, p. 71) that he found the animals "rather common in the valleys of eastern Mono County." They were feeding on the sagebrush and were exceedingly fat. The date of capture of the type was July 12, 1891 (Merriam, 1898, p. 69).

YUMA ROUND-TAILED GROUND SQUIRREL (AT LEFT); MOHAVE GROUND SQUIRREL (AT RIGHT).

## MOHAVE GROUND SQUIRREL.

### Citellus mohavensis (Merriam).

PLATE IV.

**Other names.**—Mohave Desert Spermophile; Mohave Desert Ground Squirrel, part; *Spermophilus mohavensis; Citellus tereticaudus mohavensis*, part.

**Field characters.**—A small-sized, brown-colored ground squirrel, without stripes or special markings whatsoever on the body, but with short broadly haired tail, white underneath; ear a mere rim; length of body alone, about 6½ inches, with tail about 2½ inches more.

**Description.**—Adult in full winter pelage: General tone of whole upper surface from nose to base of tail cinnamon drab; hairs on back when examined closely are seen to be lead-color at base, then ashy white, then army brown, and tipped with white; mixed with these hairs are a few of solid black color, and on the rump some which are black with a white interval near end. Eyelids white, but cheeks like back; rim of ear and upper sides of feet tinged with light pinkish cinnamon; palms of fore feet naked; soles of hind feet clothed with long buffy hairs; claws black with horn-colored tips. Under surface of body silvery white, but slaty bases of hairs show through making the general effect light gray. Under surface of the flattish stubby tail pure white; upper side like back at base, becoming mixed black and white toward end; extreme end with white fringe. Adult in summer pelage: Coat very much coarser and shorter than in winter; general color tone browner, close to cinnamon, but a grizzling effect is produced by white hair-tippings everywhere on upper surface. Sides of face paler than in winter, and lower surface of body pure white, owing to lack of lead-color at bases of individual hairs.

**Color variations.**—Specimens of dates May 3 and 12 are in process of molt from winter to summer pelage. Patches of worn and yellowed winter hairs remain on the fore back and rump. The tail is seemingly not included in the spring molt, and the old tail hairs become crinkled and broken at the ends; the white of the under side is dingy, and a dark subterminal band around the end of the tail shows through.

**Measurements.**—Average and extreme measurements, in millimeters, of seven adult specimens (5 males, 2 females), from the northern part of the Mohave Desert are as follows: Total length, 224 (212–230); tail vertebræ, 62 (42–72); hind foot, 36 (34–37); greatest length of skull, 38.6 (38.1–39.0); zygomatic breadth, 24.3 (23.6–25.3); interorbital width, 8.7 (8.2–9.2).

The two sexes appear to be alike in measurements as well as in coloration.

**Weights.**—An adult male, not particularly fat, was found to weigh 104 grams (about 3⅔ ounces).

**Type locality.**—Mohave River, California (Merriam, 1889, p. 15). More exactly, near Rabbit Springs, about 15 miles east of Mohave River at Hesperia, in San Bernardino County (Stephens, in conversation, January 1, 1916).

**Distribution area.**—Not continuous; western parts of the Mohave Desert, from Haiwee, Inyo County, south to Rabbit Springs, San Bernardino County (see fig. 18). Life-zone, Lower Sonoran, though only in its upper portion apparently. Altitudinal range, 2,500 to nearly 4,000 feet.

**Specimens examined.**—A total of 8, from the following localities in California: Inyo County: Haiwee Meadows, 3,750 feet alt., about ten miles south of Owens Lake, 2 (in coll. U. S. Biol. Surv.); Little Lake, 3,100 feet, 2 (Mus. Vert. Zool.). San Bernardino County: Salt Wells Valley (eastern edge near Inyo County line), 2,500 feet, 3 (U. S. Biol. Surv.); Rabbit Springs, 2,900 feet, east of Mohave River, 1 (in coll. F. Stephens).

The Mohave Ground Squirrel, although first discovered in 1886 by Mr. Frank Stephens of San Diego, has remained about the least known of all our rodents. Only four rather scattered localities of occurrence are definitely known, as listed above under "Specimens examined." The dates represented are March 22 and 24, May 3 and 12 and June 5.

The two specimens in the Museum of Vertebrate Zoology were trapped on the first two specified dates, in 1918, on the hillsides immediately west of Little Lake. They were daytime-taken in oat-baited rat-traps set beneath creasote bushes on gravelly ground. In spite of diligent search by the collectors everywhere in the neighborhood, not one of this species was seen alive. No information is available to us in regard to either behavior or food.

This ground squirrel is altogether distinct from *Citellus tereticaudus*. There is no indication of intergradation with that species, as stated by Elliot (1904, p. 291). In fact, the animals reported by that author from Daggett were all probably in reality *tereticaudus*, which species is known to us to be present at Daggett. The tail of *mohavensis* is always much shorter and more broadly haired than in *tereticaudus*, the claws are stouter, the cheeks are brownish instead of white, the under side of the tail is white, instead of buffy with brown mottlings toward the end, the quantity of winter pelage is greater, and the general tone of coloration is always decidedly dark.

The fact that the under side of the tail is white, as in the Antelope Ground Squirrel, leads us to suspect some such special habit of displaying this member as is possessed by the latter animal. But this is mere speculation. The relationships of *mohavensis* as indicated by structural features are thought to lie rather with *Citellus* than with *Ammospermophilus*.

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## YUMA ROUND-TAILED GROUND SQUIRREL.

### Citellus tereticaudus tereticaudus (Baird).

PLATE IV.

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**Other names.**—Round-tailed Spermophile; Yuma Ground Squirrel; Mohave Desert Ground Squirrel, part; *Spermophilus tereticaudus*; *Xerospermophilus tereticaudus*; *Citellus tereticaudus mohavensis*, part.

**Field characters.**—A small ground squirrel, of slender build, and of pale brown color (no stripes or other markings); tail long and slender, not broadly haired; ears very small, mere rims; length of body without tail about 6 inches, with tail about 3¾ inches more.

**Description.**—Adult in winter pelage: Whole upper surface from nose to and including tail, light pinkish cinnamon in general tone; individual hairs lead-colored at extreme bases, then dull white, then pinkish cinnamon, and with tipping of white. Eyelids and whole lower surface to root of tail, white; side of head and neck including ear dull white; whiskers black; hairs of belly lead-colored at extreme bases. Upper surfaces of feet dull buffy white; claws dark brown basally, becoming horn-color at tips; soles of feet haired save for under sides of toes. Tail cylindrical in shape, a little more heavily haired toward end than at base; under side dull buff, with black mottlings in fine pattern toward end; above like back on basal half, becoming black and buff mottled toward end; hairs at tip of tail brown at their bases, then buff, then broadly black, and with white ends.

Adult in summer pelage: Coat short and harsh as compared with winter coat; color above brighter pinkish cinnamon. Otherwise as in winter, but the tail, which apparently does not molt, pale brown and still slenderer, due to the fading out of the dark colors and to the wear and consequent shortening of the hairs.

**Color variations.**—Young partly grown are colored like summer adults, but the pelage is not quite so harsh and on the under surface is so sparse as to allow the bare skin to show through in places. There are two molts in the adults each year

and two distinct pelages separated by these. The spring molt occurs during April (March 28 to May 1 according to specimens at hand), and the fall molt probably during October though there are no specimens available to show its extent. The remnants of the winter pelage during the spring molt become faded in some specimens to a dull yellowish tone. This molt advances in a general way from the front backward, but specimens often show a patchy or mixed coat on the back and rump.

**Measurements.**—Average and extreme measurements, in millimeters, of seventeen adult specimens from the Colorado and Imperial valleys are as follows: seven males: total length, 247 (225–261); tail vertebræ, 95 (85–107); hind foot, 36 (34–37); greatest length of skull, 37.1 (35.2–38.2); zygomatic breadth, 23.5 (22.5–24.4); interorbital width, 8.9 (8.3–9.5). Ten females: total length, 241 (216–258); tail vertebræ, 91 (75–102); hind foot, 36 (33–38); greatest length of skull, 36.0 (34.3–38.2); zygomatic breadth, 22.2 (21.3–23.4); interorbital width, 8.6 (8.0–9.5).

Males are seen to be slightly larger than females. The ears in this species are small, the rims rising not more than 3 millimeters ($\frac{1}{8}$ inch) above their inner base. In but few specimens did the collector attempt to secure the measurement of the ear.

**Weights.**—Stephens (MS) found two females and a male to weigh together 12 ounces, an average of 4 ounces each. "All were thin."

**Type locality.**—Fort Yuma [Imperial County], California (Baird, 1857, pp. 315–316).

**Distribution area.**—Low-lying sandy areas on the Colorado and Mohave deserts. Life-zone, Lower Sonoran (see fig. 23). More specifically: the Imperial Valley west as far as La Puerta (Mus. Vert. Zool.) in extreme eastern San Diego County, north to the southern end of Salton Sea, and east to old Fort Yuma; thence north along the Colorado River nearly or quite to the Nevada line; and from the vicinity of Needles and Blythe, in the Colorado Valley, northwestward across the central part of the Mohave Desert to at least as far as Kramer (Grinnell, MS), in west-central San Bernardino County. Altitudes of occurrence, from 200 feet below sea-level to 2,300 feet above. The range of this species is not continuous over the area just indicated (see fig. 18), but consists of many colonies more or less distantly isolated from one another.

**Specimens examined.**—A total of 28 from the following localities in California: San Bernardino County, one-half mile north of Barstow, 1; Daggett, 1; Blythe Junction, 4; Needles, 3. Imperial County: south end of Salton Lake, 6; six miles south of Holtville, 2; Coyote Well, 4; Pilot Knob, 4; Colorado River opposite Cibola, 2. San Diego County: La Puerta, 1.

The Yuma Round-tailed Ground Squirrel was first made known to science in 1857 from specimens taken by an army officer stationed at old Fort Yuma, which was situated on the California side of the Colorado River opposite the present town of Yuma. It inhabits the hottest of our southeastern desert valleys. Its metropolis lies in the Imperial Valley and thence north along the valley of the Colorado; a few colonies occur also on suitable parts of the Mohave Desert. Over this general region the species is by no means continuously distributed. It seems to be very particular in its requirements, only level ground of a sandy nature being as a rule inhabited at all. Places are preferred where wind-drifted sand has been accumulated into mounds about the bases of mesquite, creasote bushes, or salt bushes. Here the burrows are to be seen opening up among the stems of the partly buried shrubs; and the animals, if not actually seen themselves, are shown by their tracks in the sand surface to be in the habit of foraging out across the bare intervals for the seeds which are to be found sifted among the sand particles.

The squirrels themselves are usually shy and by reason of their obscure coloration and especially the shimmering glare on the desert surface are not readily observed unless particularly sought for. Neither are their total numbers very great even where conditions are fairly

favorable. While our observations show them to be strictly diurnal in habits, we have noted an apparent aversion to direct sunshine. Perhaps this is because the sunshine on the desert is in summer so intense as to be quickly fatal to any small animal exposed to it for long. We know for a fact of squirrels caught in traps by one foot or merely a toe, on open ground, which have quickly succumbed—"sun-cooked" is the

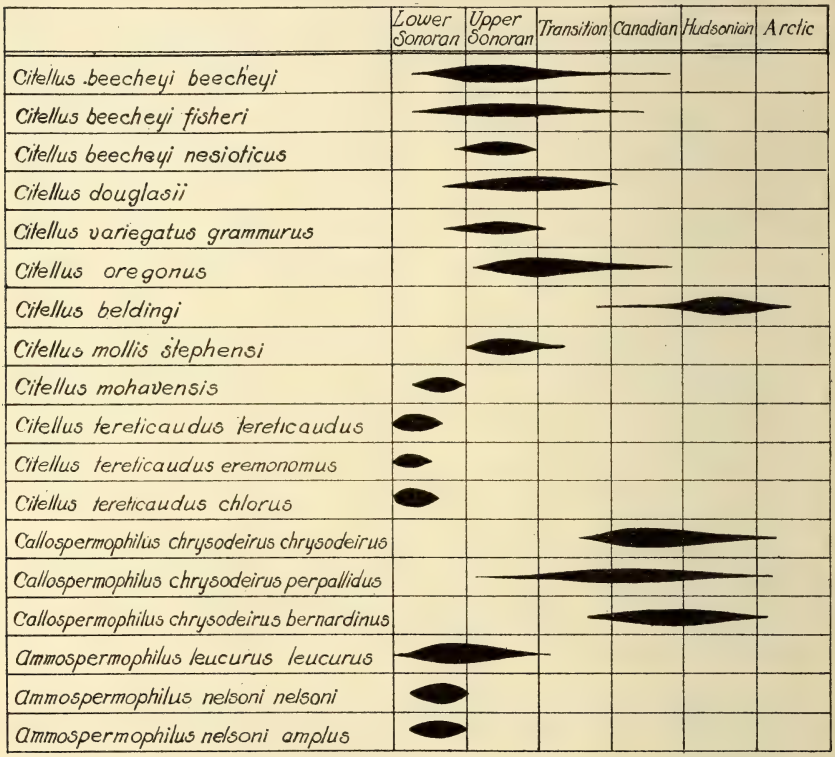


FIG. 23. Diagram showing the ranges of the ground squirrels of California according to life-zones. (For life-zone map of California, see Grinnell, 1913, pl. 15.)

term we use for such victims. At any rate, the squirrels are seen crossing open spaces but momentarily, and thenceforth they remain in the shade of bushes until they take final alarm and descend into their burrows.

The long, slender, ratlike tail is exclusively characteristic of this species of ground squirrel. The body, too, is rather slender, though after a full meal of green stuff individuals have been seen which showed a rather pot-bellied outline. The mere rims of ears give the animal a round-headed look. The movements are rather more agile than in most of its relatives. It not infrequently climbs up into bushes to a height of four or five feet, but here it becomes clumsy.

The voice of the Round-tailed Ground Squirrel is unmistakable when once learned. As far as known to us, but one kind of note is uttered, a single high-pitched squeak or shrill whistle, *seep*, uttered only at rather long intervals, never in a series as with some others of the ground squirrels. The quality of this call is such that the direction from which

it emanates is difficult to fix; also the distance is hard to determine. It seems to be given as a warning by an individual, either located within the mouth of its burrow (Stephens, 1906, p. 70) or when standing motionless under a bush. C. L. Camp (MS) records that he has seen an individual, when its curiosity was aroused, stand high up on its hind legs and utter its "sharp squeak" with the mouth wide open, at the same time "giving the thorax a violent contraction."

Facts in regard to the breeding of this squirrel are shown in the following data. On March 15 (1914) near Barstow a male Round-tailed Ground Squirrel was seen abroad which proved astonishingly indifferent. "It came up to where we were digging out a kangaroo rat colony, smelling into various burrows, evidently intently hunting for a female. The testes of this animal were enormous, dragging on the ground behind it as it waddled along" (Grinnell, MS). Two females captured in the valley of the Colorado River opposite Cibola, April 3 and 4 (1910), were found to contain six and four embryos, respectively; young about half grown were taken at Needles July 15 and 19 (1909) (Grinnell, 1914, p. 224). Stephens (1906, p. 70) says that the breeding season falls in March and April and that the number of young in a litter is four to seven. In spite of the long hot period each year in the habitat of this species, there is no evidence to show that more than one litter is reared annually.

There is a period of inactivity during midwinter, when these animals are not seen abroad. Whether or not there is regular hibernation, as with the species of colder regions, we do not definitely know; but this seems to be the case.

"The food is seeds the greater part of the year; these are stored to some extent. In the spring, during the few weeks when green vegetation is obtainable, leaves and buds are eaten voraciously" (Stephens, 1906, p. 70). In our experience, stems of the squaw-tea (*Ephedra*) and leaves of the mesquite form an important element of the diet wherever and whenever obtainable.

In June, 1918, W. C. Jacobsen (MS) found several colonies of Yuma Round-tailed Ground Squirrels in the Imperial Valley within five or six miles south of Holtville. The interesting thing was that here the animals were invading the cultivated fields and were finding alfalfa suited to their tastes. Individuals were seen to eat the leaves of the alfalfa with avidity, but left the stems uneaten. Many dry stems were found lying about near the mouths of their burrows. At another point, near Bond Corners, oat hulls were seen around burrows.

There is a possibility, therefore, that this strictly desert rodent might come to have an economic bearing on the reclaimed sections of the desert. Whether or not it will become a serious pest remains to be seen. One note of interest in this connection is furnished by Stephens (MS), who says that at Silsbee, while occasionally getting into the fields, the Round-tails were easily drowned out. As far as known to us, this species never drinks water even when within reach of it. In most parts of its range and at most seasons of the year water is secured only through chemical elaboration from its dry or nearly dry food materials. It is currently reported by the farmers in Imperial Valley that the native desert animal life quickly disappears when the land is brought under cultivation and especially irrigation.

## DEATH VALLEY ROUND-TAILED GROUND SQUIRREL.

### Citellus tereticaudus eremonomus Elliot.

**Other names.**—Death Valley Spermophile; *Citellus eremonomus.*

**Field characters.**—Exactly as for the Yuma Round-tailed Ground Squirrel.

**Description.**—As for the Yuma and Palm Springs Round-tailed Ground Squirrels, but coloration decidedly darker than in either, near wood brown. This feature is characteristic in all of the eight skins of *eremonomus* at hand.

**Color variations.**—The time of the spring molt is indicated by a specimen of date April 10, in which new summer pelage shows on the head and rump; an example of May 3 is in absolutely new summer pelage except, of course, for the tail. One specimen has a bobbed tail, with an abnormal tuft of hairs at the end, showing conspicuously a band of black and then a terminal band of white. Most of the skins show a curious spotting of the rump which is clearly not due to color markings on the hairs, but to places where hairs are absent, so that the dark-colored skin and dark bases of adjacent hairs show through. These may indicate scars from insect bites.

**Measurements.**—Average and extreme measurements, in millimeters, of eight adult female specimens from Death Valley are as follows: total length, 249 (240–255); tail vertebræ, 91 (87–93); hind foot, 35 (34–36); ear from crown, 2.1 (2.0–3.0); greatest length of skull, 36.0 (34.8–36.6); zygomatic breadth, 22.5 (22.0–23.4); interorbital width, 8.7 (8.3–8.8). No males are available.

**Weights.**—Average and extreme weights, in grams, of eight adult females from Death Valley are as follows: 144.3 (121–158). The average, in ounces, is 5.1.

**Type locality.**—Furnace Creek [Ranch], Death Valley, Inyo County, California (Elliot, 1903, p. 243).

**Distribution area.**—Floor of Death Valley, in Inyo County. Life-zone, Lower Sonoran. Only known locality of occurrence, vicinity of Furnace Creek Ranch (Greenland Ranch), —240 to —175 feet altitude. Apparently cut off from its nearest relative, *tereticaudus* proper, by the elevated rim of the Death Valley basin.

**Specimens examined.**—A total of 8, all from the near vicinity of Furnace Creek Ranch, —178 feet, Death Valley, Inyo County.

As far as known, this race of Round-tailed Ground Squirrel is limited in its distribution to the bottom of the deep sink known as Death Valley, and even there to the belt of mesquites immediately around the margin of the alkali flats at the lowest level. The entire habitat of this Death Valley subspecies thus lies below sea level, a distinction probably not shared by any other rodent in America.

Our experience with this squirrel was obtained during April and early May, 1917, in the immediate vicinity of old Furnace Creek Ranch, now known as Greenland Ranch. The animals at the time of our visit were not invading the cultivated land, though we were assured by the foreman that they had come into the alfalfa fields in previous seasons. Since this was the type locality of the subspecies, special efforts were made to obtain a series of specimens. The animals were not abundant, and proved practically impossible to trap. Shooting was resorted to, though with but little better results. The following notes were made on April 10 by the senior author while hunting them.

During a two hours hunt at midday at least five individuals were heard on the mesquite-crowned sand dunes within a mile southwest of the ranch. The warmth had seemingly brought them out, for the previous two or three days had been relatively cool, and none had been seen. A temperature of over 100° in the shade seemed to be necessary to

bring the animals out into full activity. "I caught sight of one standing upright at the mouth of its burrow, squeaking, and of two others running over the sand beneath the trailing green mesquite branches. The lines of footprints in the sand centering at the mouths of their burrows are diagnostic. The animals are extremely shy, going below ground at the slightest alarm. By standing ten minutes or so 'at attention' about fifteen yards from the mouth of a burrow down which one vanished, I finally saw the top of its head reappear to the level of its eyes. This position was maintained for many minutes, until the animal suddenly raised its whole head and neck into view, when I shot it.

"Later, while I was lying prone on the sand under a mesquite, one came up to within eight feet of me and gave its shrill, wiry cry, or squeak. A mere movement on my part, and it vanished, quick as thought." It was found that a little "screeping" (lips to back of hand) would often bring one of the squirrels stealthily investigating through the brush, provided the observer kept perfectly motionless himself and was possessed of patience. The squirrel would sometimes squeak, apparently in answer, and thus be called into very close "aux" range. The burrows were as a rule located in the periphery of a large mesquite clump, where they were shaded by the radiating leafy branches which trailed down the sandy slopes. Not more than three burrows certainly of this rodent were to be found about any one clump.

The mesquites during early April were just coming out into full new foliage. The stomachs of the squirrels shot were distended with masses of finely chewed mesquite leaves and nothing else. This, in fact, was absolutely the only kind of vegetation anywhere in sight for hundreds of yards. In one instance the total weight of the freshly killed animal was found to be 154.5 grams; of the full stomach alone, 28.7 grams, or 19 per cent (near one-fifth) of the total weight. In other words, a Death Valley Round-tailed Ground Squirrel may eat close to one-fourth its own weight of green mesquite leaves.

No young were seen by us up to the time of our departure, but they are probably born about the first of May. Two old females captured April 10 and 12 contained four and three embryos, respectively.

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## PALM SPRINGS ROUND-TAILED GROUND SQUIRREL.

### Citellus tereticaudus chlorus Elliot.

**Other names.**—Pale Spermophile; *Citellus chlorus*.

**Field characters.**—Exactly as for the Yuma Round-tailed Ground Squirrel.

**Description.**—As for the Yuma Round-tailed Ground Squirrel, but tone of coloration more grayish, avellaneous rather than light pinkish cinnamon. This difference holds through all pelages and gives the impression of an olive-colored animal, when close comparisons are made with series of the other related ground squirrels.

**Color variations.**—Specimens showing the spring molt to be in process bear dates from March 29 to as late as June 3. As with the other races of *tereticaudus* the pelage on the tail is not replaced during the spring molt and it becomes greatly faded and worn. In extreme cases the tail with its shortened, singed-looking hairs is a dirty pale brown color throughout, and as slender as a wood-rat's tail. The summer

coat is so short and thin that any scars there may be in the skin show through as dark spots. These appear irregularly on certain specimens, usually those which examination of the teeth shows to be the older individuals.

**Measurements.**—Average and extreme measurements, in millimeters, of twenty adult specimens from Whitewater, Palm Springs and Mecca, in Riverside County, are as follows: Ten males: total length, 241 (220–251); tail vertebræ, 90 (79–97); hind foot, 36 (35–40); greatest length of skull, 36.6 (35.2–38.9); zygomatic breadth, 23.0 (21.6–24.6); interorbital width, 8.9 (8.0–9.7). Ten females: total length, 240 (229–264); tail vertebræ, 89 (80–102); hind foot, 35.7 (34–39); greatest length of skull, 36.1 (35.6–37.5); zygomatic breadth, 22.8 (22.0–23.4); interorbital width, 8.8 (8.6–9.4).

**Type locality.**—Palm Springs, Riverside County, California (Elliot, 1903, p. 242).

**Distribution area.**—The northwestern arm of the Colorado Desert between Salton Sea and San Gorgonio Pass (see fig. 18). Life-zone, Lower Sonoran. More specifically, the Coachella Valley, entirely within Riverside County, from Mecca northwest to Whitewater Station; altitude from —200 to 1,130 feet.

**Specimens examined.**—A total of 41 from the following localities, all in Riverside County: Palm Springs, 6; Whitewater Station, 18; Mecca, 17.

This race of Round-tailed Ground Squirrel was first made known from specimens collected in the vicinity of Palm Springs, out on the Colorado Desert near the northeast base of San Jacinto Peak. Subsequent exploration has shown it to be limited to the relatively small area of flat desert lying between Salton Sea and the upper part of San Gorgonio Pass, and shut in narrowly by the mountain walls on either side.

The slight features by which this subspecies is distinguishable from the Yuma Round-tailed Ground Squirrel of the Imperial Valley southeast of Salton Sea may be inferred to have arisen as a result of the action of the body of water which formerly filled the Salton Sink to sea level in cutting off or isolating the animals in the northwestern arm of the Colorado Desert and thus giving them a chance to develop peculiarities all their own. The ancient predecessor of the present Salton Sea is known to geologists as Blake Sea, and this inland sea extended from the base of the Chocolate Range of mountains on the northeast to the very foot of the Santa Rosa Mountains on the southwest, thus constituting an impassable barrier to any animal closely restricted, as is the Round-tailed Ground Squirrel, to dry, level, sandy ground. However this may have been, the Palm Springs subspecies now ranges down the Coachella Valley from the northwest nearly to the upper end of the present Salton Sea, in the vicinity of Mecca. One can imagine the animal life of the desert floor now retreating, now advancing, with the fluctuations of the old Blake Sea since the time it was first cut off from the Gulf of California by the slowly growing delta of the Colorado.

The general habits of the Palm Springs Round-tailed Ground Squirrel are probably closely similar to those of the Yuma and Death Valley animals. The first-named is fairly common locally, though it rarely forces itself on the attention; it has to be specially looked for. At Mecca in March and April (1908) one or two were caught nearly every day in oat-baited rat-traps set on sandy mounds beneath mesquites. Yet the animals themselves were rarely seen. On April 26 one was surprised up in a mesquite; upon being shot it was found to have parts of a mesquite flower in its mouth. The senior author was told that at the experimental date farm near Mecca these squirrels had been seen eating the dates.

At the railroad station of Whitewater this animal was found by museum collectors to be common, June 3 to 5 (1908), in a tract of sand dunes nearby. The shrill calls or whistles were heard frequently, and many of the squirrels were trapped. Some of these were young, one-third to one-half grown. The old males and part of the old females taken then were very fat; all the rest lean. A female taken at Mecca, March 27, was found to contain five large embryos. The extent of the breeding season is thus indicated. Doubtless but one litter is raised each year.

Search in the vicinity of Palm Springs in December and January of different years has failed to show the presence of these squirrels actively abroad; so that it is likely that they hibernate during midwinter. In 1916, Swarth (MS) found them out on February 4 in a tract of sandy soil about a mile east of the village. They occurred in small scattered colonies, each "colony" marked by twelve to fifteen open holes on level ground among creasote bushes. "Parts of the burrows were shallow, so that a person would sink through into them ankle deep." The animals when alarmed would scurry to their holes and disappear into them, but would presently poke up their heads and utter "faint little barks."

No information has come to us that would indicate any decided economic bearing on the part of the Palm Springs Round-tailed Ground Squirrel. Because of its dry-land preferences it is likely that reclamation and irrigation of the land would drive it away rather than attract it. Thus the reaction would be just the opposite to that in the case of the Oregon Ground Squirrel and similar species.

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## SIERRA GOLDEN-MANTLED GROUND SQUIRREL.

### **Callospermophilus chrysodeirus chrysodeirus** (Merriam).

PLATE III.

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**Other names.**—Gilded Squirrel; Gilded Ground Squirrel; Copper-headed Ground Squirrel; Copperhead; Yellow-headed Chipmunk, part; Golden Chipmunk; Side-stripe Ground Squirrel; Bummer; Trinity Ground Squirrel; *Callospermophilus chrysodeirus trinitatis; Citellus chrysodeirus*, part; *Spermophilus chrysodeirus*, part; *Spermophilus lateralis; Callospermophilus lateralis chrysodeirus; Citellus chrysodeirus trinitatis; Tamias chrysodeirus; Tamias lateralis*, part.

**Field characters.**—A medium-sized, ground-dwelling squirrel with conspicuous stripes along sides of body; whole head more or less deeply yellow or coppery red; build stout; length of body without tail about 7⅞ inches, with tail about 3½ inches more.

**Description.**—Adult in fresh late-summer pelage: Whole top of head and hind neck, orange-cinnamon; cheek and side of neck to shoulder, ochraceous-tawny; side of snout, area around eye, ear and spot behind ear, ochraceous-buff of varying intensity; whiskers black. Two black stripes and an intervening buffy white stripe on each side of body; the whitish stripe longest, extending from shoulder over side of rump nearly to base of tail; the lower black stripe next in length, the upper shortest and it and its fellow of opposite side separated by a median band of grizzled light cinnamon-brown; this band extends from between shoulders backwards to base of tail, and expands on rump to cover flanks; side of body below lower black stripe, light buff, obscured by dusky hair-tippings. Upper sides of feet light buff;

claws blackish-brown, horn-color at tips; soles of hind feet naked nearly to heel. Chin and throat and insides of forelegs and thighs buffy white; belly with hairs extensively slaty brown at base, tipped with whitish; in other words, whitish with much slaty brown showing through. Tail well-haired, flat in form, broadest in middle portion, tapering somewhat toward end; in color, as viewed from above, chiefly black, with a margin of ochraceous-buff; there is considerable mixture with cinnamon-brown toward base, however, and separation of the hairs discloses the deeper-lying hazel color of their roots; lower surface of tail centrally solid hazel, paling to ochraceous-tawny at base of tail, then a zone of black, and then an outer fringe of bright ochraceous-buff. The body side-stripes are sharply defined along their edges, but at their ends fade out gradually; also the reddish of head blends by degrees with colors of body adjacent.

**Color variations.**—As far as we can see there is no difference in coloration between male and female, in spite of the extraordinarily bright pattern of coloration in this species. The young, even third-grown ones, are very similar to the adults in pattern, the difference consisting only in paler tones of color, especially about the head. There is, however, considerable change in the depth of coloration with season. In the spring and early summer the head region is much paler than in late summer and fall, and there is much other evidence of fading and wear to which the pelage has been subjected. In June specimens the head is pale cinnamon-buff.

As far as we can determine from the collection of specimens studied there is but one thorough-going molt each year and this takes place in June and July. The process is gradual. The exchange of old hair for new begins first on the head and progresses backwards; but specimens often show a patchy coat, with areas of dense new hair on the head or back surrounded by old worn hair.

We are unable to make out a distinguishable race from the Trinity Mountain region, *trinitatis* of Merriam, 1901, p. 126, type from "Trinity Mountains east of Hoopa Valley, California (altitude 5,700 feet)." The characters assigned, of color and size, are not borne out in our large series of specimens from the Trinity region as compared with series from the northern Sierra Nevada. There is, however, a slight tendency towards paling of colors in *chrysodeirus* at the southern end of the Sierra Nevada and along their east flank; for example, as shown by specimens from the east declivity of Kearsarge Pass, west of Independence. This modification is evidently in the direction of *perpallidus*.

**Measurements.**—Average and extreme measurements, in millimeters, of twenty full-grown specimens from the west slope of the high central Sierra Nevada are as follows: Ten males: total length, 272 (253–290); tail vertebræ, 89 (75–104); hind foot, 41 (38–43); ear from crown, 15.7 (11.0–19.0); greatest length of skull, 44.0 (42.2–46.2); zygomatic breadth, 26.6 (25.2–28.2); interorbital width, 10.4 (9.5–11.1). Ten females: total length, 266 (243–285); tail vertebræ, 83 (67–100); hind foot, 41 (39–44); ear from crown, 16.1 (13.0–21.0); greatest length of skull, 42.7 (41.0–44.1); zygomatic breadth, 25.9 (25.0–27.1); interorbital width, 10.3 (9.2–11.0).

It would appear from the above figures that in males the tail averages a little longer than in females. The skulls of old individuals, particularly males, relative age being estimated by degree of wear on the crowns of the molar teeth, show greatest size, particularly as regards zygomatic breadth and heaviness of rostrum. Old skulls also show wider brain-case, broader jugals, and stouter postorbital processes.

**Weights.**—Average and extreme weights, in grams, of twenty full-grown specimens from the west slope of the high central Sierra Nevada are as follows: Ten males, 181 (155–218); ten females, 199 (136–245). Averages, in ounces: males, about 6½; females, about 7.

The heaviest example (245 grams) was a pregnant female. Males average heavier in the fall, when they are fat, than in early summer.

**Type locality.**—Fort Klamath [mountains near], Klamath County, Oregon (Merriam, 1890, p. 19).

**Distribution area.**—Upper coniferous belt (Canadian and Hudsonian life-zones, less commonly down into Transition) along the Sierra Nevada, south as far as Cannell Meadows, in extreme southern Tulare County; north through the Mount Lassen country to Mount Shasta, and thence west through the Trinity, Scott and Salmon Mountains (Mus. Vert. Zool.) to extreme eastern Humboldt County (Merriam, 1901, p. 126); also on the Siskiyou Mountains, along the Oregon border of western Siskiyou County (Merriam, 1901, p. 126); on the mountain mass to the

south of the Trinities, in the vicinity of Yolla Bolly Mountain, where Humboldt, Tehama and Mendocino counties adjoin; and on the Warner Mountains, in eastern Modoc County (Mus. Vert. Zool.). The range of the Golden-mantled Ground Squirrel in northern California is probably less continuous than indicated on the map (fig. 24), there being sequestered colonies on detached mountains along with similarly isolated representations of other boreal animals and plants.

Altitudinally, this squirrel extends regularly to above timber-line, where the mountains are high enough for this, and downwards to the lower edge of the chinquapin belt, that is, scarcely as far as the yellow pines or Douglas firs. At the farthest south, in the Mount Whitney region, it has been noted as high as 11,800 feet, while downwards it was not seen below 7,000 feet. In the latitude of Yosemite, the highest point at which it was observed was 10,700 feet, and the lowest, Merced Grove of Big Trees, 5,500 feet. In the Trinity region, the lowest occurrence noted was at 4,500 feet altitude. There is thus a notable lowering of altitudinal limits with increased latitude.

**Specimens examined.**—A total of 259, from the following localities in California: Modoc County: ten miles northwest of Canby, 1; Sugar Hill, 11; Parker Creek and North Fork Parker Creek, Warner Mts., 9; Warren Peak, Warner Mts., 7; Dry Creek, Warner Mts., 1. Siskiyou County: head of Little Shasta River, northeast base Goose Nest Mt., 2; Mount Shasta, 10; Kangaroo Creek, 1; Wildcat Peak, 3; Jackson Lake, 5; Saloon Creek Divide, 11; Castle Lake, 2; head of Rush Creek, 6; South Fork Salmon River, 8. Trinity County: Bear Creek, 11; North Fork Coffee Creek, 3; head of Grizzly Creek, 5; one-half mile south of South Yolla Bolly Mt., 3. Lassen County: Eagle Lake, 2; Horse Lake, 1. Tehama County: two to four miles south of South Yolla Bolly Mt., 19; Mount Lynn, 2. Plumas County: Mohawk, 1. Sierra County: near Sierraville, 1. Nevada County: Independence Lake, 5. Placer County: Tahoe Valley, 2; Cisco, 13; two miles west of Soda Springs Station, 1. El Dorado County: Mount Tallac, 1. Mono County: Leevining Creek, 1; Walker Lake, 1; Bloody Canyon, 1. Tuolumne County: Ten Lakes, 1; Glen Aulin, 1; Tuolumne Meadows, 4; head of Lyell Canyon, 2; Aspen Valley, 2. Mariposa County: Vogelsang Lake, 1; Porcupine Flat, 3; one mile east of Merced Lake, 1; near Mono Meadows, 2; Mount Clark, 1; Merced Big Trees, 5; East Fork Indian Canyon, 1; Chinquapin, 3. Inyo County: Little Onion Valley, 1; Onion Valley, 4; Hockett Trail (near Carroll Creek), 2; Little Cottonwood Creek, 4; Cottonwood Lakes, 6. Fresno County: Kearsarge Pass, 5; Bullfrog Lake, 8; Bubbs Creek, 1; Horse Corral Meadow, 2. Tulare County: Siberian Pass, 1; west slope Cirque Peak, 1; Whitney Creek, 3; Whitney Meadows, 13; west slope Olancha Peak, 1; Dry Meadows, 1; Monache Meadows, 7; Jackass Meadows, 14; Sirretta Meadows, 3; Cannell Meadows, 5.

Of all our ground squirrels the Golden-mantled is the most brilliantly colored. This rather bookish name for the animal is a translation of the scientific name of the species, *chrysodeirus*; the more commonplace appellations locally employed, "Copperhead" or "Yellow-headed Chipmunk," serve just as well to set forth the conspicuous feature of coloration. Because of the bright colors and especially the striping of the body (see fig. 20d), this ground squirrel is often called "chipmunk;" but the latter name applies to a quite different group of animals which are slenderly built, agile, with long tails, and more numerous body stripes which involve the head as well as the body.

The Golden-mantled Ground Squirrel is truly a ground squirrel in essential features of appearance and behavior as well as structure. Although it lives for the most part in forested regions, it keeps strictly on the ground when traveling or feeding, and only ascends rocks or logs when seeking a lookout station. The species, including its three subspecies in California, is confined to the higher mountains. One does not meet with it, in climbing the slopes, usually until well through the yellow-pine belt. Individuals begin to appear with the firs, and from there on to the upper limit of timber this species constitutes one of the most conspicuous features of the life of the forest floor. Here

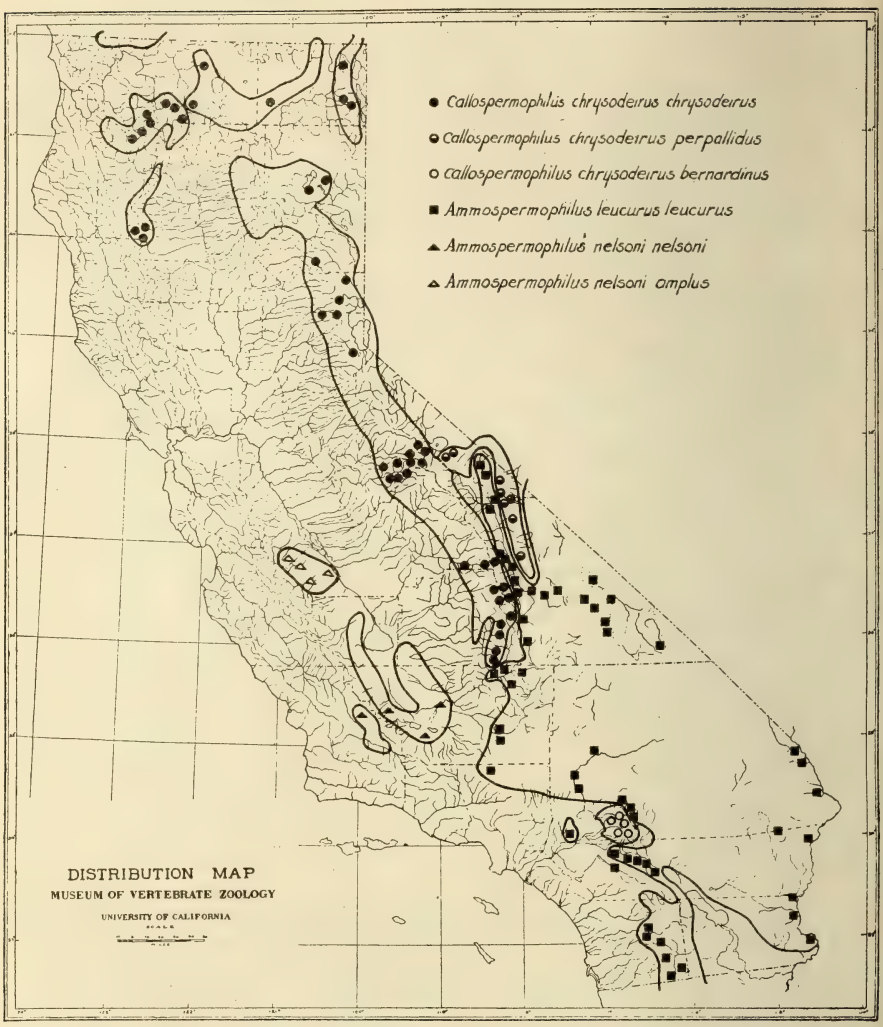


FIG. 24. Map showing California distribution of the golden-mantled and antelope groups of ground squirrels. The spots represent localities from which actual specimens have been examined.

the animals are to be seen scurrying across open spaces to their burrows, just in front of the mouths of which they almost invariably stop a moment before plunging out of sight, displaying then to full advantage their color pattern. If the observer traverses their domain quietly, he may suddenly discover individual squirrels intensely observing him from perches on the tops of boulders or logs. There they sit in unostentatious, hunched-over postures, blending so well with the background that they are often passed by altogether unnoticed. The element protecting them from observation most, at such times, seems to be their faculty for keeping absolutely still.

Rarely do Golden-mantled Ground Squirrels assume the upright picket-pin pose so characteristic of some others of the species. They most often maintain crouching attitudes when at rest. When running, the gait is clumsy, as compared with the chipmunks usually to be seen close at hand. The tail is rather longer than in others of the smaller sized ground squirrels, and is more conspicuously displayed, often up over the back, or, when running, either held vertically or frisked violently fore and aft. This squirrel seems to be, as a rule, almost devoid of voice. As far as our own experience has gone, there is only a single *chirp* of alarm, not loud nor high-pitched, and even this is uttered but rarely. One observer (W. P. Taylor, MS) has been fortunate enough to run across a talkative individual. This animal was watched as it sat bolt upright on a log uttering a "sharp call note, *to-chick,* sometimes varying this to *tachack, p'r'r'r'r.*" A "general squirrel-like quality" was ascribed to these notes. At each utterance a violent flirt of the tail was given.

Speaking of habitat again, the Golden-mantled Ground Squirrel shows decided preference for rocky slopes or forest floors littered with logs, but at the same time without heavy undergrowth. *Open* ground is preferred; yet it keeps out of large grassy meadows, save as visiting the margins of these where they adjoin the woods. Again we see adjustment so that each of the different kinds of rodents keeps to a separate forage area without undue waste of energy in competing with another. In the higher, rougher parts of the mountains we have often found the Copperheads inhabiting rock slides. Here, as in the other places, where there are logs or scattered rocks, the object appears to be to secure protection for their burrows, so that these can be located beneath heavy objects and thus prove difficult or impossible for badgers, coyotes or bears to dig out.

The mouths of the burrows vary in diameter from 2 to 2½ inches, and the direction taken is usually steeply down into the ground for a foot or more. Unfortunately, we have never availed ourselves of an opportunity to dig out the burrow system of a Golden-mantled Ground Squirrel. We infer it to be simple and relatively short, for two reasons: the mounds at the mouths of the burrows are usually small in quantity of earth composing them; and the big roots, logs or rocks beneath which the burrows in practically all cases lead, would seem to do away with the need of an extensive and deeply penetrating system so as to secure safety from enemies which pursue their prey by digging.

The Golden-mantled Ground Squirrel is a spermophile in the truest sense of the word; it is preëminently a gatherer and eater of seeds, and most of its time aboveground seems to be occupied in diligent search for this sort of food. The cheek-pouches in this squirrel are developed to a maximum degree, and it is no uncommon thing to see an individual returning to its burrow from a foraging expedition with its two pouches so distended with seeds that the head seems double its ordinary width. We have counted 636 seeds from the two pouches of one squirrel.

Some seeds identified in cheek-pouch contents saved are: Goose grass (*Galium aparine*), rice-root lily (*Fritillaria* sp.), pentstemon (*Pentstemon azureus*), and silver pine (*Pinus monticola*). In the late summer and autumn months great activity is shown in garnering chinquapins, and there seems good reason to believe that large stores

of these and various seeds are then housed away in the ground for use the following spring when the animals come out of hibernation and food is difficult to find otherwise. One individual had its cheek-pouches crammed with fragments of a brown-colored fungus such as forms bracket-like outgrowths on the bark of dead trees and old logs. Our experience shows this article of diet to be much sought after by members of the squirrel tribe generally.

Then, too, the Golden-mantled Ground Squirrel eats meat, and even carrion, as we can testify from the persistency with which our meat-baited steel traps set for coyotes and other carnivores are sprung by the Copperheads. Indeed, it seems reasonable to infer that this ground squirrel would lose no opportunity to appropriate to its use the dead remains of any sort of animal. Around camp sites we have often received good evidence of the omnivorous nature of the Copperhead's diet from seeing them gathering the scattered barley from the ground where the horses had been fed and then gleaning the scraps of cooked meat as well as bread crumbs from our own table near by. In one case a "Callo" came again and again to gnaw at a bacon rind. The young, but a third grown, show almost as much industry in carrying away food as do the adults.

That not all the food gathered, over and above what is immediately eaten, is carried to some definitely located storehouse, is shown by an observation by W. P. Taylor (MS). On the summit of Cloud's Rest, Yosemite Park, a "Callo" was encountered which was so used to the almost daily visits of people as to have become remarkably tame. It would run up to within three feet of a person, take the dried fruit thrown down for it, stuffing its cheek-pouches to capacity, and then run off just a little ways. After digging out a little hollow in the ground with its front feet, it placed the fruit therein and proceeded to cover it up with earth, using its front feet again. Sitting over the spot, it reached out to gather in additional loose stones until the cache was effectually concealed. Such hiding places as these are probably used only temporarily, at times when an abundance of food is suddenly available, to be stowed safely from someone else's reach as soon as possible, and later reclaimed for more permanent salvage.

The young are born mostly in July, but as early as the last of June at the lowest altitudes of occurrence, and as late as the first week of August up near timber line. Young one-half grown were taken on Cannell Meadows, 7,500 feet altitude, Tulare County, on July 7, 1911; and young but a third grown were taken at Cottonwood Lakes, 11,000 feet, near Mount Whitney, August 31, 1911. These dates are the extremes in the considerable series we have for time of appearance of young. Young come above ground when they are as small as one-fourth adult size (as determined by weighing). There is but one litter each year. This probably averages close to five in number. Six females captured along the central Sierras, of dates June 12 to 28, contained 5, 2, 5, 6, 6 and 5 embryos, respectively. The number of mammæ (represented by nipples) is either four pairs or five pairs, but this number is not, as some persons think, any index to the number of young born.

The enemies of this squirrel probably include most of the carnivores of the higher mountains. Hair of a "Callo" was found in the feces

of a Mountain Coyote (*Canis latrans lestes*) in the Yosemite National Park. Near Monache Meadows, in the Sierras of eastern Tulare County, one of the writers saw a Mountain Weasel (*Mustela arizonensis*) in full pursuit of a "Callo" across open ground in the full sunshine of the bright forenoon of August 4, 1911. The squirrel was overtaken by the weasel, and what happened transpired so swiftly that no details were observable. A gunshot terminated the episode, and the "Callo" was found already stone dead, with two tooth-punctures on each side of the nape of its neck.

The Golden-mantled Ground Squirrels hibernate regularly. They doubtless construct warm, dry nests underground, as individuals have been seen gathering soft materials and carrying these to their burrows. In one instance an individual was seen to pick up a piece of brown paper and after tearing it with its teeth and forepaws, stuff it into its cheeks and disappear into a burrow (C. L. Camp, MS). By the last of August these ground squirrels begin to acquire fat, and during September and October they are simply "rolling in butter," as the saying goes. This seems to be in preparation for their long period of dormancy, which extends from the last of October to the middle of April.

Exact dates of going into, and coming out of, their winter sleep are not available to us. But in the Yosemite region in 1915 individuals were seen abroad in the Canadian life-zone commonly up to October 18; on October 30, in the same zone, but two individuals were seen on the same ground where very many were noted a month previously; and none at all were seen on subsequent dates when they were looked for at suitable altitudes. The estimate of April 15 as near the time of reappearance in the spring is based on what we have been told by trappers and forest rangers, and their statements were only from memory.

Since the territory inhabited by the Golden-mantled Ground Squirrel is practically altogether above the altitudinal limit of cultivation by man, this species rarely figures as anything worse than a camp-robber or "bummer" (see fig. 20d). We have heard packers complain of its proclivities in the way of carrying off grain or provisions from summer camps in the higher mountains. But the total destruction of property thus wrought can hardly be formidable, and compensating for it to some degree must be counted the added animation lent to the mountain scene by the presence of these pleasing rodents.

## INYO GOLDEN-MANTLED GROUND SQUIRREL.

### Callospermophilus chrysodeirus perpallidus Grinnell.

**Other names.**—Sierra Golden-mantled Ground Squirrel, part; Yellow-headed Chipmunk, part; *Callospermophilus chrysodeirus*, part; *Spermophilus chrysodeirus*, part; *Citellus chrysodeirus*, part.

**Field characters.**—Exactly the same as for the Sierra Golden-mantled Ground Squirrel, save for pallor of coloration.

**Description.**—Adult in fresh late-summer pelage: Pattern of coloration and chief features throughout precisely as in the Sierra Golden-mantled Ground Squirrel, but general tone of coloration paler; middle of back, rump and sides tending towards

ashy, head less richly coppery, and under surface of body and upper surfaces of feet whiter; under surface of tail medially ochraceous-tawny. Because the lighter colors are paler in tone, the jet black side-stripes stand out with greater sharpness than in the Sierran race.

**Color variations.**—As in the Sierra Golden-mantled Ground Squirrel. In some specimens in fresh pelage the throat is pure white without a tinge of buff. Half-grown young just out of their nest-burrows show the characteristic paleness of their subspecies to as great a degree as adults in new coat. The pallidness of the adults in old worn breeding dress is greater in degree than in the Sierran race, evidently due to the greater bleaching effects of the more intense sunlight and dryness to which the Inyo animals are exposed. The innate paleness of the Inyo race is thus accentuated by external factors.

**Measurements.**—Average and extreme measurements, in millimeters, of twenty full-grown specimens from the White Mountains, Mono and Inyo counties, are as follows: Ten males: total length, 268 (260–279); tail vertebræ, 92 (80–105); hind foot, 40 (38–43); ear from crown, 13.4 (11.0–15.0); greatest length of skull, 42.9 (42.0–44.0); zygomatic breadth, 26.2 (25.0–26.9); interorbital width, 10.0 (9.0–11.3). Ten females: total length, 264 (254–286); tail vertebræ, 85 (78–89); hind foot, 38 (36–42); ear from crown, 13.3 (10.0–16.0); greatest length of skull, 41.4 (39.6–42.3); zygomatic breadth, 25.9 (25.0–26.6); interorbital width, 9.8 (9.3–10.2).

As will be seen from the above measurements in comparison with those given for the Sierran race, there are no important size differences between *perpallidus* and *chrysodeirus;* indeed it seems likely that, with large enough series, such discrepancies as are here in evidence would disappear altogether. The same variations due to age and sex seem to be present.

**Weights.**—Average and extreme weights, in grams, of twenty full-grown specimens from the White Mountains, Mono and Inyo counties, are as follows: Ten males, 182 (166.5–199.5); ten females, 160 (141.0–209.1). Averages, in ounces: males, about 6½; females, about 5½.

There were no gravid females in this lot. All were taken before August 10 and so none had become very fat. These facts may account for the lesser weights than shown for the Sierran race.

**Type locality.**—White Mountains at 10,300 feet altitude, near Big Prospector Meadow, Mono County, California (Grinnell, 1918, p. 429).

**Distribution area.**—The upper portions of the arid mountain ranges of extreme eastern California lying east and north of Owens Valley, namely the Inyo and White Mountains, and the mountain mass lying southeast of Mono Lake. Northernmost station, Mono Craters, Mono County (Mus. Vert. Zool.); southernmost, summit of Inyo Mountains east of Lone Pine (Elliot, 1904, p. 288). Along this extent of territory the distribution of the animal is not continuous but is interrupted at the lowermost gaps between the Inyo and White Mountains and at the extreme head of Owens Valley. Zonally, this race belongs to Boreal, but it extends down locally as low even as Upper Sonoran (see fig. 23). In other words, it extends from above timberline down to as low as 7,000 feet altitude (lower edge of piñons), the latter level for it being recorded from the bottom of Silver Canyon east of Laws. The highest observed station of occurrence is McAfee Meadow, 11,600 feet, near White Mountain Peak (Mus. Vert. Zool.).

**Specimens examined.**—A total of 50, from the following localities in California: Mono County: Mono Mills, 4; Mono Craters, 1; McAfee Meadow, White Mts., 7; Big Prospector Meadow, White Mts., 22; Cottonwood Creek, White Mts., 1. Inyo County: Roberts Ranch, Wyman Creek, White Mts., 2; Silver Canyon, White Mts., 4; Black Canyon, White Mts., 5; Mazourka Canyon, Inyo Mts., 4.

This is simply a pale desert-range race of Golden-mantled Ground Squirrel, probably cut off but incompletely from its near relative, *chrysodeirus,* of the Sierra Nevada. There can hardly be expected to be any decided differences in habits between the two; yet the different "setting" of *perpallidus*—exceedingly dry, rocky slopes, with only sparse timber at best—has left in our minds an impression of distinctness. This only goes to show that we cannot conveniently, nor should

we properly (from a scientific standpoint), consider any animal altogether apart from its normal surroundings.

In the Inyo Mountains this squirrel was found by H. S. Swarth (MS) to range from the level of the lowest piñons in Mazourka Canyon, about 7,500 feet altitude, to the highest summit visited by him, 10,500 feet. In the White Mountains, east of Laws, the senior author found it to range down Silver Canyon to as low as 7,000 feet altitude, and here this and the Antelope Ground Squirrel of the lower country overlapped in their ranges to a small degree. The "Callos," in such precipitous canyons as Silver Canyon, were essentially "rock" squirrels, in that they had their retreats in the slides of shale rock at the bases of the cliffs and even in the broken rock outcrops far up the canyon walls. Through and along these they clambered, a bit clumsily perhaps, but without loss of foothold so far as was seen.

Higher up, on the lofty rolling plateau forming the summit of this mountain range, the Golden-mantled Ground Squirrels were extremely abundant along the edges of the stunted forests of foxtail and lodgepole pines, and even far from timber out on the sagebrush flats, but in the latter locations there were always near at hand fractured granite outcrops which afforded safe retreats. Where there were grassy meadows the animals foraged all over them. It occurred to the observer that here in the White Mountains there was but this one species of ground squirrel and that *it* therefore had the run of the whole place, as it were, without meeting with any competitor, as is the case in the Sierras and elsewhere. This would account for the facts as observed, namely, that in the White Mountains the Copperheads were extraordinarily abundant and ranged widely into all sorts of associations.

Our lines of rat-traps baited with rolled oats brought in many "Callos," even youngsters but a third grown, and it was practically impossible to keep steel traps set during the day, as the bait, consisting of the bodies of the various birds and small mammals prepared for specimens, seemed to be especially attractive to the squirrels. Wherever the traps were set, they would be searched out and unwittingly sprung as the squirrels scrambled over them in quest of the bait. It seemed impossible that the "Callos" could have located some of the settings except through scent, and it is reasonable to suppose that the sense of smell *is* employed not only in seeking meat but when searching for the bulbs of certain plants.

Young were out in numbers the last week of July at the 10,000-foot level, being then one-third to one-half grown. Lower down, in Black Canyon at 8,000 feet altitude, half-grown young were seen on July 5 (1917); and at 10,500 feet altitude, on Cottonwood Creek, third-grown young were noted on August 8. This shows the usual variation of appearance of young with altitude, which of course has to do with advance of the season, and so with temperature.

In Mazourka Canyon, Inyo Mountains, two females, each containing six embryos, medium-sized and small, respectively, were taken May 19 and 22 (1912). We found no evidence of litters of a larger number than six; and there is certainly no more than one litter per year.

## SAN BERNARDINO GOLDEN-MANTLED GROUND SQUIRREL.

### Callospermophilus chrysodeirus bernardinus (Merriam).

**Other names.**—San Bernardino Ground Squirrel; San Bernardino Spermophile; Yellow-headed Chipmunk, part; *Spermophilus bernardinus; Spermophilus chrysodeirus brevicaudus; Citellus chrysodeirus bernardinus; Callospermophilus bernardinus; Tamias chrysodeirus brevicaudus; Tamias lateralis*, part.

**Field characters.**—The same as for the Sierra Golden-mantled Ground Squirrel. The slight shortness of tail characterizing this race is certainly not a sufficient difference for notice at any distance.

**Description.**—In all pelages: Coloration, as far as we can see after comparing large series of specimens, exactly as in the Sierra Golden-mantled Ground Squirrel. None of the paleness is apparent such as characterizes the Inyo race.

**Variations.**—Of the same sort as discussed under the Sierran race.

**Measurements.**—Average and extreme measurements, in millimeters, of twenty full-grown specimens from the San Bernardino Mountains are as follows: Ten males: total length, 260 (240–278); tail vertebræ, 80 (68–90); hind foot, 40 (36–43); greatest length of skull, 43.5 (42.0–45.6); zygomatic breadth, 26.6 (25.5–27.6); interorbital width, 10.7 (10.1–11.3). Ten females: total length, 251 (236–271); tail vertebræ, 78 (72–86); hind foot, 38.5 (35–42); greatest length of skull, 41.8 (40.4–43.0); zygomatic breadth, 25.5 (24.2–26.8); interorbital width, 10.2 (9.7–10.8).

Unfortunately, ear measurements from fresh specimens are not available; but dried skins *look* to have decidedly smaller ears than in either the Sierra or Inyo race, this character being especially noticeable in the young. It will be noted from the above measurements in comparison with those given for *chrysodeirus* and *perpallidus*, that the body size of *bernardinus* is just the same as in the others, while the tail length is decidedly less. This, then, is *the* character of the subspecies *bernardinus*, shortness of tail; and it shows up well in a series of specimens, even very young ones. However, this difference in tail length between adults of *bernardinus* and of *chrysodeirus* averages but somewhat less than half an inch, and individual variation brings overlapping in a certain proportion of specimens. In other words, an extra short-tailed *chrysodeirus* might even have a longer tail than an extra long tailed *bernardinus*. The race *bernardinus* is but slightly and incompletely differentiated.

No weights are available for this subspecies.

**Type locality.**—San Bernardino Peak, San Bernardino Mountains, San Bernardino County, California (Merriam, 1893, p. 134).

**Distribution.**—Restricted to the relatively small area, not more than twenty-five miles in greatest width, comprised in the higher parts of the San Bernardino Mountains (see fig. 24). Belongs to the Boreal zone and upper part of the Transition. Extends up to the very summit of San Gorgonio Peak, 11,485 feet altitude, and down locally, as near Bear Lake, to 6,700 feet (Grinnell, 1908, p. 141).

**Specimens examined.**—A total of 84, from the following localilties, all in San Bernardino County, California: San Gorgonio Peak, 2; Dry Lake, 3; South Fork of Santa Ana River, 14; Sugarloaf Mountain, 2; Bluff Lake, 61; Bear Valley, 2.

Far separated by desert and lowland from the habitat of its near relative on the Sierras, the Golden-mantled Ground Squirrel of the San Bernardino Mountains has developed slight peculiarities which make it recognizable as a distinct race. It has the most restricted range, probably, of any species or subspecies of ground squirrel in the state. It seems strange that it should be wholly lacking as an inhabitant of the San Gabriel and San Jacinto mountains, so near by on either hand and seemingly of quite similar environment to the San Bernardinos. On the higher parts of the San Bernardino Mountains it is certainly not on the wane, but thrives greatly, perhaps outnumbering all the other members of the squirrel family put together.

In July, 1905, we found the Golden-mantled Ground Squirrels especially numerous around Bluff Lake, altitude 7,500 feet. Here they were to be seen all over the floor of the pine and fir woods, foraging among the chinquapin and deer-brush thickets. None was ever seen to climb a tree, though individuals were often seen perched motionless on stumps, logs or boulders. No matter where encountered, they always sought safety in holes in the ground or in crevices among rocks. They were notably quiet animals, giving only occasionally a single sharp note of alarm, or else, rarely, a low chuckle.

FIG. 25. San Bernardino Golden-mantled Ground Squirrel as taken from nest while dormant during period of hibernation. Note that the animal is curled into an almost globular shape, with head down and nose snuggled against stomach between fore and hind feet; tail curled underneath, partly concealing head.

Around Bear Lake the Yellowheads were common through the woods down to the water's edge. On the north slopes of Sugarloaf, on August 22, they were very busy gathering cheek-pouchfuls of seeds of a lupine, and the fruits of the deer-brush (*Ceanothus cordulatus*) and of a reddish-fruited currant (*Ribes* sp.). Elsewhere they were seen carrying to their burrows quantities of the green burrs of the chinquapin (*Castanopsis sempervirens*). The burrows usually opened out under logs, rotten stumps, or boulders. There was seldom any mound of earth to mark an entrance.

A female squirrel captured at Dry Lake, 9,000 feet altitude, on June 22, was found to contain four embryos. The young must have

been born generally during the early part of July, in a few cases as late as early August, to judge from the relative sizes of the young seen abroad. The first to appear aboveground were noted on July 17 at Bluff Lake. These were about one-third grown and seemed quite able to forage independently of their parent. The latter paid no attention whatever to them, only giving the sharp alarm note if an intruder was sighted.

Two young ones trapped alive were taken home to Pasadena and kept in a cage. Early in the autumn one killed the other. The remaining individual survived for three years, latterly inhabiting a rock-pile in the yard and ranging freely where he would. Each winter he spent about seven months, October to April, inclusive, in hibernation (see fig. 25), with only occasional periods of activity for a day or two during spells of warm weather. It is interesting to note that this inclination to lie dormant was thus shown strongly at the low altitude of Pasadena, where the winter temperature scarcely ever reached the freezing point. There could have been no practical reason for it as regards failure of food, for a supply was always provided the animal in abundance. The annual program seems to require the dormant period, and this comes on at a regular time, and lasts the usual period, whether or not it happens to be essential to the survival of the individual. It is an inherited trait of the race.

## DESERT ANTELOPE GROUND SQUIRREL.

### Ammospermophilus leucurus leucurus (Merriam).

PLATE V.

**Other names.**—Antelope Chipmunk, part; Antelope Squirrel; Harris Chipmunk; White-tailed Spermophile; Charming Spermophile; Ammo; *Tamias harrisi; Spermophilus harrisii; Tamias leucurus; Citellus leucurus; Spermophilus leucurus; Citellus leucurus vinnulus; Citellus vinnulus; Ammospermophilus leucurus vinnulus.*

**Field characters.**—A small grayish brown ground squirrel with one white stripe on each side of body and with a short flat tail nearly always held cocked up over its rump so as to show the white under side conspicuously. Length of body alone about 6 inches, tail about 2½ inches more.

**Description.**—Adult in winter pelage: General color effect on upper surface from nose to base of tail light brownish drab, changing on shoulders, flanks and outer sides of fore and hind legs to light pinkish cinnamon. Close inspection shows a grizzling due to variegation of colors on the individual hairs, these being, on middle of back for example, plumbeous at extreme base, then pale gray, then black, then brown, and finally white-tipped; some of the hairs on sides and rump are longer than the average and black to ends. A sharply-defined narrow white stripe on each side of body from shoulder to side of rump. Eyelids white; ears and sides of head buffy white; whiskers black. Whole lower surface of body, from chin to root of tail, silvery white, the bases of the hairs lead-color. Soles of hind feet densely white haired forward to tubercles (see fig. 26a), thence to balls of toes naked, and plumbeous in color in dried specimens; outer sides of hind feet and tops of fore feet tinged with pinkish cinnamon; feet otherwise dull white; claws blackish brown with pale horn-colored tips. Tail broadly haired and blunt-ended, narrowed at base; above mixed black and white, giving an iron-gray effect, but, analyzed in its terminal half, an outermost white border is seen to be preceded inwardly by a black band, then by a white band, then centrally by black; toward the root of the tail, above, there is a tinge of pinkish cinnamon, this overlaid with a grizzling as on the back. Under

DESERT ANTELOPE GROUND SQUIRRELS (AT LEFT); FISHER GROUND SQUIRREL (AT RIGHT).

surface of tail broadly pure creamy white, with an outer black border around the terminal half, and succeeding this a white fringe.

Adult in summer pelage: Coat short and harsh instead of long and silky. General pattern of coloration as in winter, but tone of upper surface more buffy, especially so on top of head; hairs on whole lower surface pure white to bases (no lead-color); tail as in winter.

**Color variations.**—The sexes are alike in coloration. The young closely resemble summer adults save that the pelage is not so harsh. There is some individual variation in tone of gray on back and in intensity of cinnamon on flanks and shoulders, but we are unable to find any correlation in these respects with locality. In other words, we are unable to find any tendency within the range of *Ammospermophilus leucurus* in California to form subspecies. The range of the animal is continuous from the Mexican border to the head of Owens Valley and there are no hindrances to continuous mixing of breed, such as seem essential to subspecific differentiation in other ground squirrels.

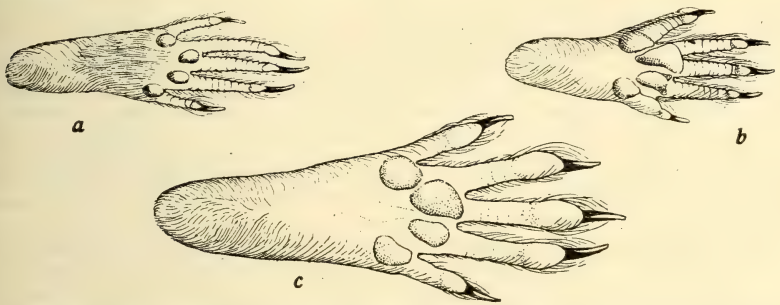


FIG. 26. Feet of ground squirrels to show extent of hairing on soles and position and shape of tubercles. *a*, Desert Antelope Ground Squirrel; *b*, Stephens Soft-haired Ground Squirrel; *c*, California Ground Squirrel. Natural size; drawn from specimens.

The two seasonal coats, winter and summer, are interchanged through a clearly defined process of molt. That from winter to summer begins as early as April 23 and continues in different individuals as late as June 18; that in the fall extends from September 12 to October 23. These dates are as shown by the specimens available. The spring molt commences on the forehead and proceeds backwards; the last remnants of the winter coat are to be seen on the hind neck and rump. In the fall the order is reversed, and the rump first acquires the new winter pelage, the crown and forehead being the last areas to show the short harsh summer hairs. The hairs of the tail seem to be involved only in the fall molt, in other words they are not replaced in the spring when the rest of the pelage is.

Wear, fading, and contact with alkaline soil bring about some modification in the tones of coloration. In some cases the tails are dirty light brown and the ends of the hairs are all curled up as if scorched by heat. In April specimens from the sand-dunes at the edge of Owens Lake near Keeler, the worn winter pelage shows a curious yellowish tone, but September examples from the same place, in process of molt, show the new winter pelage to be normal and exactly like that in specimens from Riverside County.

We are unable to find any grounds for recognizing a separate race of *leucurus* from the Inyo region (*vinnulus* of Elliot, 1903, p. 241, type from Keeler, Inyo County).

**Measurements.**—Average and extreme measurements, in millimeters, of twenty adult specimens from Inyo County are as follows: Ten males: total length, 215 (200–235); tail vertebræ, 61.5 (50–70); hind foot, 37.7 (35–40); ear from crown, 5.7 (5.0–7.0); greatest length of skull, 38.7 (37.5–40.6); zygomatic breadth, 22.3 (21.5–23.1); interorbital width, 9.6 (9.4–10.1). Ten females: total length, 211 (200–220); tail vertebræ, 57.7 (46.0–65.0); hind foot, 36.5 (35.0–38.0); ear from crown, 5.5 (4.0–8.0); greatest length of skull, 38.1 (37.1–39.4); zygomatic breadth, 22.1 (20.6–22.9); interorbital width, 9.6 (8.9–9.9).

Males seem to be a little larger than females, on an average, with proportionally longer tails. We are unable to find anything in our material to indicate variation in measurements with either altitude or latitude within the state of California.

**Weights.**—Average and extreme weights, in grams, of twenty adult specimens from Inyo County are as follows: Ten males, 104.4 (94.5–120.7); ten females, 104 (83.6–115.0). Average in ounces, for both males and females, about 3⅝.

**Type locality.**—San Gorgonio Pass, below [east of] Banning, Riverside County, California (Merriam, 1889, p. 20; Stephens, 1906, p. 75).

**Distribution area.**—In general, the southeastern desert region (see fig. 24). Life-zone chiefly Lower Sonoran, but extends locally up through Upper Sonoran and even into Transition (see fig. 23). More specifically, the Colorado and Mohave Deserts (not, however, in some of the sandier or low-lying parts) from the Mexican line on the western rim of the Imperial Valley and the vicinity of Picacho on the lower Colorado River, north to the extreme head of Owens Valley in the vicinity of Benton, Mono County (Mus. Vert. Zool.).

Along the western edge of the area inhabited by this squirrel, it extends well up onto the sides of the confining mountains and often far through the passes, as far as arid conditions prevail; for example, in San Gorgonio Pass, Riverside County, above Cabezon, and over Walker and Kelso passes, in Kern County, down the valley of the South Fork of the Kern River to as far at least as Weldon (Mus. Vert. Zool.), thus well over the rim of the San Joaquin basin. There are in southern California at least two outlying colonies on the Pacific side of the desert divides; namely, in San Jacinto Valley, Riverside County (Grinnell and Swarth, 1913, p. 326), and in Lytle Creek wash within six miles northwest of San Bernardino, in San Bernardino County (Mus. Vert. Zool.).

Altitudinally, the species ranges from below sea-level, as at Furnace Creek Ranch, —178 feet, in Death Valley, up regularly to 6,000 feet on most of the desert mountains which reach that height, and in some instances to 7,500 feet, as at the north base of Sugarloaf in the San Bernardino Mountains (Grinnell, 1908, p. 141), and even to 8,500 feet, as near the head of Mazourka Canyon, in the Inyo Mountains (Swarth, MS).

**Specimens examined.**—A total of 271, from the following localities in California. Mono County: Benton, and two miles south of Benton Station, 11. Inyo County: Laws, 6; Silver Canyon, White Mts., 9; Mazourka Canyon, Inyo Mts., 5; Independence, and two miles north of Independence, 19; west base Kearsarge Pass, Sierra Nevada, 4; Lone Pine Creek, 4,500 ft., 10; Carroll Creek, 5,500 ft., and Hockett Trail, 6,500 ft., near Carroll Creek, 4; Keeler, 31; Olancha, 2; Darwin (fifteen miles, and two miles, north of), 7; Panamint Mts. (Emigrant, Wild Rose, Hanaupah, and Johnson canyons), 17; Furnace Creek Ranch, and Triangle Spring, in Death Valley, 13; Shoshone, 2; Little Lake, 2. Kern County: Weldon, Onyx, and west slope Walker Pass, 16; one mile east of Warren Station, 1; Mohave, 12. Los Angeles County: Fairmont, 8. San Bernardino County: one mile northeast of Barstow, 1; Oro Grande, 2; mountains on west side of Colorado River, lat. 35°, 1; Blythe Junction, 1; five miles below Needles, 1; opposite The Needles, 5; Chemehuevis Valley, 2; Victorville, 14; San Bernardino Mts. (Cushenbury Springs, Cactus Flat, Doble, north base of Sugarloaf), 17; Cajon (Lytle Creek) Wash near San Bernardino, 1. Riverside County: base of San Jacinto Mts., near Cabezon, 7; Snow Creek, near Whitewater, 5; Vallevista, San Jacinto Valley, 4; Palm Springs, 7; Carrizo Creek and Dos Palmos Springs, Santa Rosa Mts., 5; Palm Canyon, San Jacinto Mts., 1; Riverside Mt., near Colorado River, 1. San Diego County: San Felipe Valley, 2; Grapevine Spring, 1; La Puerta, 2; Vallecito, 2; Jacumba, 1; Mountain Spring, 1. Imperial County: Colorado River, opposite Cibola, 2; twenty miles north of Picacho, 4; eight miles east of Picacho, 2.

The Antelope Ground Squirrels constitute a group distinct in many ways from all our other species. They are hardly less inhabitants of the ground, as compared with the tree squirrels and true chipmunks, but in manner they are more vivacious than any of the other ground squirrels; they run at a much faster clip and hence can forage at greater distances from safety refuges. Their coloration is distinctive, too, gray, with one white stripe along each side of the back, and with the

under side of the tail brilliantly white. This latter feature is in itself unique, for it is accompanied by a most striking mannerism, that of the almost constant carriage of the stubby, flat-haired tail in an upright position, held against the back, so that the white under surface shows as a white "flag" when the animal is scurrying away, much as with the similarly advertising marks of the cottontail rabbit and antelope; only with the ground squirrel the effect in catching the eye of the observer is still further heightened by the way in which it is spasmodically twitched whether the animal be at rest or running. This flickering beam of white ever holds the attention as long as the squirrel is below the level of the horizon, and short of its burrow or the concealing tangle of prickly vegetation which it is so anxious to put between it and its pursuer.

The race called appropriately Desert Antelope Ground Squirrel (locally, Antelope "Chipmunk" because of its stripes, small size and sprightly manners) occurs broadly over the Colorado and Mohave deserts, thence north clear through the Inyo region. It shows rather wide adaptability to the varying conditions in this vast area, more so than any other desert ground squirrel, and ranges from below sea level, as on the floor of Death Valley, up regularly to 6,500 feet on the steep slopes of the desert mountains. It even "spills over" the confining rim of the Mohave Desert to the westward, locally, on to the Pacific drainage, as shown in detail in the accompanying list of specimens and on the map (fig. 24). Although notably continuous in its range over great stretches of country, it is not difficult to discover preferences, as indicated by relative abundance. Level sandy ground is, as a rule, but sparsely inhabited; and we know of some stretches of desert, such as the floor of the Coachella Valley northwest of Salton Sea, where none at all seem to exist, although the species is abundant in the foothills adjacent. The kind of ground most generally preferred seems to be hard-surfaced, gravelly wash-fans or hill slopes. Kinds of vegetation present seem to be immaterial, though clumps of squaw tea, creasote bush, cactus, or tree yucca characterize much of the territory where the Antelope Squirrels are most abundant.

Our mention of the above preferences must not give an erroneous idea as to special nature of the habitat of this species. It may be said again, for emphasis, that this animal thrives in a great variety of situations. We have seen it on the mesquite-crowned sand dunes of Death Valley, there as a companion of the Death Valley Round-tailed Ground Squirrel; on the sagebrush covered flats at the extreme head of Owens Valley, in the metropolis of the Stephens Soft-haired Ground Squirrel; on the creasote hillsides near Little Lake, one of our very few record stations for the Mohave Ground Squirrel; among the piñons and granite boulders of the northern section of the Panamint Mountains, then associated with the big Fisher Ground Squirrel; and even upon the steep rocky slopes of the White Mountains at 7,800 feet altitude, in the same rock slides with the Inyo Golden-mantled Ground Squirrel! Truly a cosmopolite is the Antelope Ground Squirrel, just so far as the dry atmosphere of the desert extends; but the coastal fog and general humidity of the Pacific drainage are almost strictly taboo.

The burrow of this rodent is in nearly all cases situated at the side of a dense brush-clump or boulder so that protection is afforded from

predators that dig, such as badgers and coyotes. The mouth of the burrow is kept open, and is flush with the surface of the ground; and there is usually no trace of any mound. Sometimes there is a small pile of fresh earth adjacent to a hole, but this is subject to quick dissipation by the winds or the much more infrequent rains. The mouth of the burrow is subtriangular in outline, the flattish base of the triangle horizontal at the bottom. It is not often circular, as with pocket gophers and kangaroo rats, and usually can be recognized accordingly. There is evidence that these squirrels use the burrows of other rodents, too, such as those of wood rats, kangaroo rats, and even badgers. And in places where such retreats are afforded, individuals seem to have their headquarters in the interstices of rock slides. Suffice it to say that in the Antelope Ground Squirrel we do not find a good digger. It takes a temperamentally phlegmatic animal to dig effectively. The "Ammos" are too fidgety.

This species does not live in colonies in the restricted sense in which this term should be used, but the burrows are scattered out pretty evenly over the general territory occupied. There is less of interdependence between the individuals of this species than in most other ground squirrels.

In traveling through their domain one *sees* few of these ground squirrels as compared with their real numbers. They are adepts at dodging behind bushes, and at eluding observation by skipping off out of sight considerably in advance of the intruder. For example, in a census of animal life taken near Mohave, March 14, 1918, during a three-hour walk, but two Antelope Squirrels were seen, whereas six were found to have been caught in a line of rat-traps during the same length of time. Then, too, the characteristic tracks in the sand on a quiet day after it has been laid by a norther leave a graphic record of the multitudinous peregrinations of these active rodents. They can make more tracks in a given length of time than any other mammal with which we are acquainted!

Some notes made by the senior author the second week of March, 1918, near Mohave will help to give a clear idea of the characteristics of the animal under discussion. Nearly all individuals seen would run very fast across open spaces between the bushes, but would hesitate a moment or so when passing through the bushes. When approaching its burrow each animal would stop stock still just short of the mouth of the burrow, and watch the intruder intently with head turned to one side sufficiently so that it could look back past its rump. Meanwhile the tail was vibrated intermittently as usual. Presently the animal would dive down out of sight. One was seen to go down into a hole situated in the side of a mound of sand accumulated about the base of a very large creasote bush. This hole was one yard from the nearest upright stem, but was directed downward diagonally toward the root-system, and it was overshadowed by the radiating branches. The diameter of this burrow at its mouth was just 40 millimeters (about one and three-fifths inches). The last that was seen of another squirrel as he dived for his burrow, he had his tail over his back twitching as violently as ever. He, too, had hesitated just an instant before the final plunge.

One individual was surprised eight feet above the ground in a tree yucca, where he had doubtless been prospecting among the ripe pods for the seeds. He ran down the yucca trunk head foremost, with clearly audible noise of claws on rough bark. Even in this position the tail was kept appressed to the rump and was flicked in fore-and-aft direction. This ability to climb is not exceptional among individuals of this species, and is quite consistent with the general agility of the animal. Near Keeler, on the morning of September 25, 1917, six individuals were seen severally in the tops of sarcobatus bushes evidently gathering the small, fleshy leaves. At the distant approach of the observer each scurried to the ground and each had altogether disappeared by the time he had come up. At Onyx, Kern County, June 21, 1911, one was seen perched on the top of a fencepost. At Carroll Creek, near Owens Lake, September 8, 1911, several were seen at different times perched bolt upright, picket-pin fashion, on isolated boulders out on the mesa.

As a general thing Antelope Ground Squirrels do not have access to water and they live for long periods without it. Like other typically desert rodents, they can secure all the water needed in their systems by chemical elaboration of their food materials. Yet that water is sought for where available is shown by the following instances: When camped at a spring near the head of Kelso Valley, Kern County, July 8, 1911, the senior author saw an "Ammo" come without hesitation to the lowest hoofprints containing water below the spring and drink five times; each time about ten seconds were apparently occupied in lapping. At intervals the animal looked around, vibrating his tail the while with great rapidity. At least six other individuals came to drink during that day, arriving through the brush from considerable distances. One of these, observed closely, was seen to lap hurriedly and briefly eight times.

Some observations made at the same time and place bear further on the behavior of this species of ground squirrel. When one is stalked it will make a dash of ten feet or more to a near-by shrub or rock. If the observer continues to advance the squirrel disappears down a hole or under a bush, or else makes another similar dash and stops again. It then either stands on all fours with its back humped up toward the intruder and its head turned around so as to watch, or it stands upright on its haunches, turning more toward the observer. In either case the tail is held over the back and is wiggled, either antero-posteriorly or laterally. The tip of the tail, at least, shows no constant direction of movement. "When entering a burrow I saw one individual drop his tail down behind him and trail it into the burrow instead of carrying it over his back" (Storer, MS). Often when running an "Ammo" will be seen to jump short distances, quite clearing the ground. "I saw one in a tree yucca where I only came to detect his presence by seeing the shadow of his wiggling tail" (Storer, MS). The animals seem to be able to climb the prickly cactuses and yuccas without sustaining any serious injury.

The voice of the Antelope Squirrel is unique among the members of its tribe. It is not a "bark" at all; nor is it a "squeak." It may be described as a prolonged mellow rolling trill, weakening or falling in inflection toward the end. The tone is maintained on about the same moderately high pitch throughout, though an impression of lowering

may be received because of the progressive diminution in volume. The sound is of a quality to carry well, yet even at very close range it rarely sounds loud. The direction of the performer is usually hard to fix. This shifting, ventriloquistic quality goes well with the shimmering landscape and elusive behavior of the animal, with which it is usually associated in our experience.

The breeding season begins about the first of March and, in its various phases, lasts ordinarily until the end of May. At the highest altitudes the program is evidently retarded some because of the later advent of warm weather. There is nothing to indicate that more than one litter is produced each year by one female. The instances of late appearance of young (for example, in August), where not accounted for by altitude, would seem likely to be due to individual variation in time of development of the reproductive instincts or else to abortion or early death of the first litter. The following is the more or less exact breeding data given in the field notes on file in the Museum of Vertebrate Zoology.

The earliest date for embryos is February 20 (1910) near Needles on the Colorado River; the number of embryos was eight. On March 11 (of the same year), in Chemehuevis Valley, south of Needles, a female was taken containing five embryos. The weather was yet cold, ice on standing water at night. It seems to be a rule with the squirrel family in the desert that the breeding season is so timed that the young of the year are well grown long before the period of intensest summer heat.

March 11 to 16 (1918) thirty Antelope Squirrels were trapped or shot in the vicinity of Mohave. Of these, seventeen were males and thirteen were females, all adult and in breeding condition. The testes of the males were huge, measuring up to three-fourths of an inch in length. The uteri of the females were heavy-walled, but in only one case were there yet any embryos; one taken March 11 contained five well-developed embryos. The males were lean; the females all more or less fat. On March 18 (1914) at Victorville two females were taken containing thirteen and fourteen embryos, respectively. On March 27 (1907), at the same place, a female was found to contain eight embryos. On April 6 (1918), at Olancha, two females contained nine and ten embryos, respectively; and on April 12 one was found to contain seven embryos. On April 24 (1912) at Keeler a female was taken which contained six embryos.

The average number of young per litter as figured from the above records of embryos is close to nine, with five and fourteen as extremes. Stephens (1906, p. 75) considers five to eight as the usual number. Nelson (1918, p. 443) gives four to twelve. Mearns (1907, p. 301) records that near Mountain Spring, in May, 1894, ten small young of uniform size were caught from one hole.

The mammæ are generally in five pairs, occasionally in six, rarely five on one side and six on the other.

The earliest date we have for the appearance of young aboveground is April 23 (1917) at Furnace Creek Ranch, Death Valley; one youngster scarcely one-fifth grown (its weight was but 17.7 grams) was found wandering about weakly under a mesquite (see fig. 27). The next date is May 13 (1908) for third-grown young at Cabezon, and records for

the last week of May are numerous. The latest date is September 4 (1908) for half-grown young at Vallevista, San Jacinto Valley. From all the facts at hand we would estimate the usual date of birth for this species to be close to May 10.

By the time they are half grown the young seem to be well able to forage for food by themselves. No solicitude has been observed on the part of the parent. The young show themselves to be less shy than adults, and for this reason it is probable that a large toll is taken by their enemies during early summer, until the young get sophisticated.

The Antelope Ground Squirrel, according to the data above given, is the most prolific of all our species of ground squirrels. It can be inferred from this that existence on the desert, in the mode followed

FIG. 27. Desert Antelope Ground Squirrel, about one-fifth grown, found wandering about weakly under a mesquite at Furnace Creek Ranch in Death Valley, April 23, 1917. Photographed by J. Dixon. Although very young and feeble this little squirrel persisted in holding its tail at all times over its back in characteristic Ammospermophilus fashion.

by this squirrel, is the most precarious. The factor of high mortality must therefore be provided against by high birth rate. The category of predaceous animals which occupy the same territory and which are sure to prey habitually upon the Antelope Squirrel includes "snakes, weasels, foxes, coyotes, badgers, bobcats, and many kinds of hawks" (Nelson, 1918, p. 443).

At all the lower elevations, where the winters are not especially cold, Antelope Ground Squirrels are to be seen abroad at all seasons. For instance, around Victorville in December and January, 1904-05, and at Palm Springs in December, 1904, they were to be seen nearly every day, though they did not seem to be foraging far and wide actively then as is their wont in March and later. At the former locality on the coldest windy days none was seen. It is very likely that at higher places, altitudinally, especially where there is some snow, as at the head of Owens Valley, these animals hibernate through the coldest months.

The fact that there is a special winter pelage, long, full and silky, would seem to have some meaning as an accompaniment of outdoor activity at that season. Certain it is, that in texture, the pelage of the Antelope Squirrels is quite different from that of those species which hibernate regularly and long. The latter are woolly, with much under-fur. In the fall and winter "Ammos" are uniformly very fat. This condition is probably maintained by drawing upon their food stores, which, to judge from their persistent industry earlier in the season, must be extensive. We have never taken the opportunity to dig out the burrows to see how the seeds and other foodstuffs are garnered. Interesting facts doubtless await inquiry in this direction.

The Antelope Ground Squirrel is preëminently a gatherer of seeds and fruits. The two inside-opening cheek-pouches are extensive, doubtless on this account. Rarely does an animal captured away from its burrow fail to show something in them. The following records of findings of this nature will give a good idea of the diet of the species.

In the tree-yucca belt near Mohave, March 11 to 16, 1918, many of the squirrels examined were carrying the large flat black seeds of the tree-yucca (*Yucca brevifolia*). These seeds were being gathered for the most part from the ground, where they had fallen from the pod-clusters overhead. But in a few cases the squirrels were seen up in the yuccas going right after the ripe pods themselves. The greatest number of these seeds being carried at one time was seventeen, this in the case of a male taken on Lee Flat, fifteen miles north of Darwin, September 28, 1917. A female taken in Walker Pass, June 27, 1911, contained in its cheek-pouches 98 shelled seeds of juniper (*Juniperus californicus*). A female captured at Keeler, April 28, 1912, had gathered into her cheek-pouches 178 husked seeds of the salt-grass (*Distichlis spicata*).

Cactus seeds are frequently gathered, and, in season, the fleshy fruits are eaten. At Vallevista, San Jacinto Valley, September 4, 1908, the squirrels were feeding chiefly on the ripe cactus "pears." The animals were well stained with the purple juice both outside and in; the whole abdominal region was purple in some of the individuals skinned for specimens. At Cabezon, May 6, 1908, a squirrel was watched in the top of a cholla cactus eating the tender new-growth buds. The animal seemed to be able to move about without its feet being injured by the spines, but upon being shot a thorn was found sticking firmly in the roof of its mouth.

This squirrel also gathers, doubtless for food, the stems of squaw-tea (*Ephedra*), cut into sections, and the leaves of *Sarcobatus*. Immediately after rains, when the evanescent annual vegetation of the desert starts to grow, sprouting plants of certain species are also gathered.

Judging from the frequency with which Antelope Ground Squirrels get into meat-baited traps, they must have a decided taste for flesh. We have also frequently found them eating into the bodies of rodents already caught and killed in small traps, and in one case, at least, one of its own kind was the victim. Nelson (1918, p. 443) says that insects are eaten when occasion offers.

As for cultivated crops, it is not often that Antelope Ground Squirrels are to be found in settled regions, and even where they are, they do not seem to be attracted by the conditions which accompany irrigation. For example, around Cabezon in San Gorgonio Pass, in May, 1908, the

farmers and orchardists reported that little or no damage was done by this rodent, although the big Fisher Ground Squirrel was a decided pest there. The little Antelope "Chipmunks" seemed to keep closely to the wild land, feeding upon the native seeds and fruits, especially those of the cactuses.

Still, locally, they may prove noticeably destructive. This was the case in an almond orchard near Fairmont in northern Los Angeles County, where in June, 1904, the present authors saw the animals climbing the trees in the outer rows next to the wild land and carrying down the as yet unripe almonds. These and the Fisher Ground Squirrels were both complained of bitterly by the owner. Again, in Owens Valley near Independence, on May 7, 1912, a male Antelope Ground Squirrel was captured, with its cheek-pouches filled with wheat. The nearest grain field was a quarter of a mile distant. It is thus quite to be expected that where cultivated land adjoins wild land this species will make raids upon such crops as prove to its liking.

## NELSON ANTELOPE GROUND SQUIRREL.

### Ammospermophilus nelsoni nelsoni (Merriam).

**Other names.**—Nelson Spermophile; Nelson Ground Squirrel; Antelope Chipmunk, part; *Spermophilus nelsoni*; *Citellus nelsoni.*

**Field characters.**—A small yellowish-brown ground squirrel with one narrow white stripe on each side of body, and with a short flat tail nearly always held curled up over the rump so as to show the creamy white under side. Length of body alone about 6¼ inches, tail about 2⅝ inches more.

**Description.**—Adult in summer pelage: General color of upper surface from nose to base of tail light clay color, brightening toward pinkish cinnamon on shoulders, flanks, and outer sides of fore and hind limbs; a narrow white stripe on each side of body from shoulder to side of rump. Eyelids, ears and sides of head dull buffy white; whiskers black. Whole lower surface of body white, the hairs white to bases; soles of feet densely white-haired forward to tubercles, thence to balls of toes naked; upper surfaces of feet white, buff tinged; claws blackish brown with pale horn-colored tips. Tail as in *leucurus*, but upper side near base clay color; under surface creamy or buffy white centrally. Adult in winter pelage: Coat softer, the hairs being longer and more silky than in summer. General coloration as in summer, but tone of upper surface a little darker, and with a fine grizzling due to more variegated color pattern on the individual hairs. White hairs of lower surface with extreme bases lead-color.

**Color variations.**—Sexes alike, as far as we can see. Young colored as in the summer adults, but pelage finer in texture.

**Measurements.**—Average and extreme measurements, in millimeters, of twenty full-grown specimens from the vicinity of Bakersfield, Kern County, are as follows: Ten males: total length, 226 (210–242); tail vertebræ, 70 (61–76); hind foot, 38.6 (36–40); ear from crown, 5.3 (5–6); greatest length of skull, 39.9 (39.0–41.6); zygomatic breadth, 23.2 (21.4–25.0); interorbital width, 9.9 (9.5–10.4). Ten females: total length, 221 (203–238); tail vertebræ, 68 (64–74); hind foot, 38.4 (35.0–41.0); ear from crown, 5.7 (5.0–6.0); greatest length of skull, 39.4 (37.8–41.3); zygomatic breadth, 22.6 (21.5–24.4); interorbital width, 9.7 (9.0–10.6).

Males will be seen from the above figures to average slightly larger than females. The decidedly greater size of *nelsoni* as compared with *leucurus* is at once apparent.

**Weights.**—Three adult females were found to weigh 141.8, 142.6, and 179.0 grams, respectively; average, 154.5 grams, or 5½ ounces. In bulk *nelsoni* is thus about 50 per cent larger than *leucurus*.

**Type locality.**—Tipton, Tulare County, California (Merriam, 1893, p. 129).

**Distribution.**—Occupies the floor of the southern end of the San Joaquin Valley, and adjacent arid hills and included valleys immediately to the westward (see fig. 24). Life-zone Lower Sonoran. More specifically, extends from vicinity of Bakersfield (8 miles northeast) and Poso, in central Kern County, west to the Carrizo Plains and Cuyama Valley, in southeastern San Luis Obispo County, south to the mouth of San Emigdio Creek, 12 miles due east of Maricopa, Kern County, and north to Huron, Fresno County, and Tipton, Tulare County.

**Specimens examined.**—A total of 43, from the following localities in California. Kern County: eight miles northeast of Bakersfield, 32; twelve miles due east of Maricopa, 5; McKittrick, 3. San Luis Obispo County: Carrizo Plains, 3.

The Nelson Antelope Ground Squirrel is called Antelope Chipmunk by many of the people who live in the southern San Joaquin Valley. No distinction is made by them between the present species and the Antelope Squirrel of the Mohave and Colorado deserts. This is not surprising when we consider the rather close general resemblance between the two. When specimens of the two animals are in hand, tone of coloration alone suffices for distinguishing them. The ground color of the Nelson Squirrel is distinctly clay color, while that of the Desert Antelope Ground Squirrel is pinkish buff. In the former, too, the under side of the tail is creamy buff, while in the latter it is pure white. In bulk the Nelson is approximately 50 per cent the larger.

The Tehachapi Mountains on the south and the Greenhorn Mountains to the east help to form a continuous barrier between the range of these two near-related squirrels. We find the Nelson Squirrel to be restricted for the most part to the Lower Sonoran life-zone in that portion of the San Joaquin Valley which lies south of Tulare Lake. It is notably numerous in the oil districts. The Nelson Squirrel may be distinguished from all other rodents that occur in this region by having a very short, flat-haired tail (less than 3 inches in length) and by the presence of a single white stripe on each side of the body. The name borne by this species was given to it by its original describer (Merriam, 1893, p. 129) as a recognition of the contributions to mammalogy of Edward W. Nelson, now chief of the United States Bureau of Biological Survey.

During the rainy season many of the smaller streams in the southern and western foothills around the San Joaquin Valley cut deep and narrow channels, but when the flood waters of such streams reach the upper plains of the great valley their course is marked by broad washes with low, perpendicular banks. The silt-bearing waters finally spread out, forming broad, alluvial fans, and often sink into the thirsty soil before they reach the lower alkaline plains. The lower reaches of such stream courses, dry and desertlike most of the year, are the preferred haunts of the Nelson Ground Squirrel. Here burrows are easily dug between the hard layers of the stratified banks of the washes, affording safe retreats from such predators as the coyote and badger. A luxurious though brief-lived growth of vegetation results from the thorough natural irrigation of the rich soil of the alluvial fans and the squirrels are thus afforded an abundant food supply the rest of the year. Individuals and even colonies are to be found along the little gullies and ridges of the upper slopes between the mouths of the streams and the foothills, while a few may be found along the edges of the alkali ground

of the lower levels; but the metropolis of the species is in the middle region among the salt-bushes (*Atriplex*) which thickly dot these plains.

This ground squirrel is soon driven out when fields come under cultivation. It clings closely to the wild land and apparently rarely if ever invades adjoining ground which may happen to be under cultivation. Thus in May, 1918, at the mouth of San Emigdio Creek, Kern County, we found these squirrels quite abundant on three sides of an extensive alfalfa field which was entirely surrounded by virgin tracts of the salt-bush (*Atriplex*), yet during our stay of nearly two weeks, not a single Nelson Squirrel was observed to enter this field or even to touch a leaf of the alfalfa.

As usually encountered, the Nelson Squirrels are seen scurrying rapidly across open places between clumps of salt-bushes, or else, more rarely, standing straight up to their full height in true "picket-pin" fashion just before they disappear down their burrows. The normal mode of travel is by a series of short rapid jumps of from 6 to 12 inches. When approaching a hole leisurely, or when foraging about, the animals sometimes slow down into a walk.

These squirrels are not early risers, being rarely found abroad until well after sun-up. At the mouth of San Emigdio Creek, during the second week in May, Nelson Squirrels began to appear at the entrances to their burrows in the south-facing overhanging bank of a wash, between 8 and 8:15 in the morning. They appeared earlier in the day at this point than elsewhere in the vicinity, doubtless because this bank first received the full force of the early morning sun. Ten o'clock marked the period of greatest activity. The squirrels under observation disappeared each day between 11:30 and 12 o'clock and were rarely seen again until 2:30 in the afternoon, when they began to reappear in the shade of certain dense-foliaged salt-bushes that grew on the brink of the wash. Although they were frequently seen to bask in the rays of the early morning sunshine, these squirrels shunned the direct sunlight at noonday. As early even as 10 o'clock in the morning one female was seen repeatedly to seek shelter in the shade of a fencepost (J. Dixon, MS).

The tail of the Nelson Antelope Squirrel, as with the Desert Antelope Squirrel, is the most conspicuous feature about the animal. When running, the tail is curved forward over the back, in which position the creamy under surface is most effectively displayed so that at a distance one receives the impression that merely a bit of thistledown is blowing along over the sand. The body of the animal, with its ground-like tone of color, practically disappears. This illusion is furthered by the twitching of the tail and by the momentary pauses of the animal which correspond closely with the usual interrupted flight of a tuft of thistledown.

When the squirrel is foraging about on all four legs, or else sitting up, the tail is held curved forward over the back; in fact, one rarely sees the tail held in any other position (see fig. 28). At such times the tip of the tail is often curved slightly upward or outward. When excited or frightened the tail of the animal is twitched rapidly fore and aft, but rarely or never sideways. One individual observed at a distance of ten feet was seen to vibrate its tail intermittently with exceeding rapidity, there being half-minute intervals between the periods of

vibration. There were from four to six of these periods of vibration in a series. The tip of the tail would travel only a short distance, less than a couple of inches, as it was never seen to reach a vertical position above the animal's back when the squirrel was standing on all fours.

These squirrels are notably cautious about coming out of their holes; they were never seen to come out hastily. First the nose and then the eye of an animal would stealthily appear, and then a thorough look around for possible danger taken, before a squirrel considered it safe to leave the shelter of its burrow. However, when they do move, their actions are very sudden, as though they had been undecided just what to do, but having once made up their minds are off in a whirl of dust. These rodents are more easily alarmed by sound than by sight. The

FIG. 28. Young Nelson Antelope Ground Squirrel, photographed by J. Dixon, May 9, 1918, on lower San Emigdio Creek, Kern County. Note how well the general color of the animal blends with the tone of the background, and yet how strikingly the white of the under side of the tail shines forth.

cracking of a twig would send them hot-footed to their burrows. Yet the observer was able to walk up to within thirty feet of them in plain sight in the open as long as he made no violent motions. By approaching slowly and directly towards the squirrels, it was frequently possible to get within ten feet when they were sunning themselves at the entrances to the burrows under the overhanging banks.

The sense of smell seems to be extensively used in the daily life of these animals. At the close approach of the observer the noses of these little squirrels were seen to twitch constantly as if in effort to catch the scent of the stranger. The sense of smell also plays an important part in locating food. Then again it is used socially. When following each other about, in and out of the burrows, they often stop and sniff to see

which way the other has gone. Smell serves as a means of identifying the other members of the same family. Outsiders are quickly detected and promptly driven away. The members of one family of squirrels which was closely watched were found to be very sociable, never quarreling among themselves. The parents were often seen sitting side by side feeding in perfect harmony (see fig. 29), while at other times this pair would sit together and rub noses in a very affectionate way. The only time that they were seen to show fight was when a strange male squirrel attempted to enter their burrow, and then the male of the pair promptly put the intruder to flight.

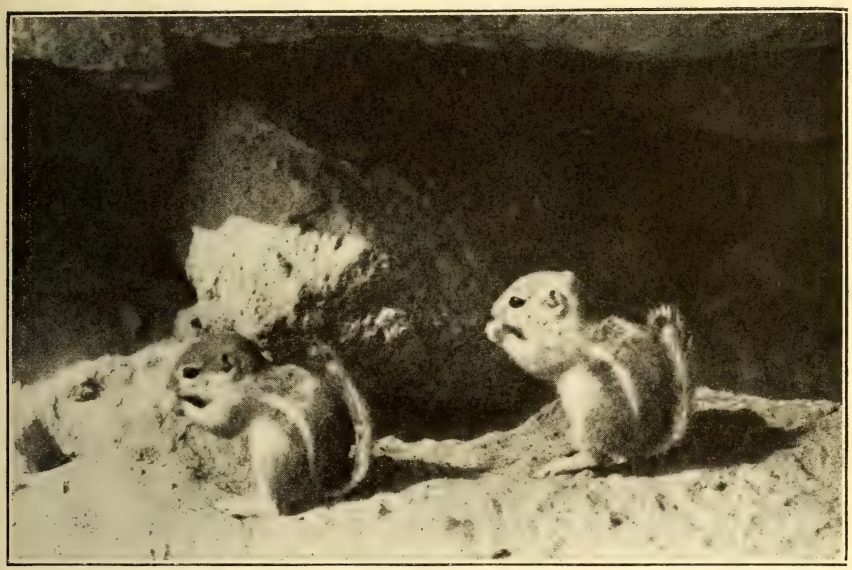

FIG. 29. Adult male and female Nelson Antelope Ground Squirrels, feeding in harmony side by side under wholly natural conditions. Photographed by J. Dixon, May 9, 1918, on lower San Emigdio Creek, Kern County. The openings under the horizontal layers of the wash banks afforded these squirrels safe retreats. Note the characteristic Ammospermophilus pose of body and tail.

The alarm note of the Nelson Antelope Ground Squirrel is much subdued as compared with the clear penetrating trill of the Desert Antelope Ground Squirrel. In fact, the former is much less frequently heard at all. While the junior author was watching a family of Nelson Squirrels at play on the morning of May 8, 1918, an old female was seen to disappear into one of the numerous holes in the bank. About two minutes later his attention was attracted by the low, inquisitive *chirr* of this same squirrel, which was standing motionless less than ten feet behind him. This alarm note was repeated five or six times at intervals of from 30 to 45 seconds. In uttering this note the mouth was opened, but the effort was not convulsive nor was the thorax greatly contracted. The note was subdued in tone and probably not audible to human ears at a distance exceeding one hundred feet. The confidential quality of the call note reminded the observer very much of the clucking note of the female valley quail when keeping her young together.

Numerous holes in the sides of gullies and in the banks of washes form the most conspicuous signs of the presence of the Nelson Squirrel. Tracks and mounds at the entrances to burrows are not as noticeable as one would expect from the number and size of the animals. Trails from the burrows to the feeding grounds of this species are usually not well defined. In one place near the mouth of San Emigdio Creek these squirrels were obliged to cross a large dusty area in traveling back and forth between their burrows and their feeding grounds. Numerous tracks in this dusty spot showed that the squirrels in this colony did not follow definite trails, but that each individual chose his own route. In passing around a projecting bank, however, the tracks were found to converge for a short distance into broad, well-beaten paths six to eight inches wide.

The favorite location for burrows of this squirrel is, as already stated, in the sides of banks at the edges of washes or gullies. The burrows usually enter near the bottom of the bank. The entrances to the burrows vary from 1½ to 8 inches in diameter. The largest holes are in soft ground beneath horizontal hard strata in the bank and their large diameter is due at least in part to the weathering or caving in of the soft earth. The burrows of smallest diameter are found in hard, level ground at the roots of *Atriplex* bushes. The entrances to burrows in the banks are from six inches to fifty feet apart. These bank burrows run back in a generally horizontal direction and are interconnected to a considerable extent under the bank. This was proven by seeing a certain squirrel, known by sight to the observer, disappear into one hole and then in a few minutes reappear at the mouth of an adjoining burrow twenty or more feet distant.

All of the eight burrows dug into by various persons from this museum have proven to be simply refuge burrows, with only one entrance; that is, not of the intercommunicating type. Squirrels were found to reappear in from 5 to 15 minutes after they were chased into such burrows. These refuge burrows were found to be short, less than twelve feet in length; shallow, less than three feet in depth; and of small size, less than two inches in diameter. In three cases the squirrels were gassed in these burrows and an hour later dug out. Two of the animals were found dead near the wasteball at the entrance of the burrow, where they had evidently been overcome by the gas when attempting to make their way out.

No nests were found in any of the burrows that were dug out, although nesting burrows were particularly sought for. Consequently we have no information to offer regarding this phase of the animal's life history.

The Nelson Squirrels found near the mouth of San Emigdio Creek were found to be moderately infested with fleas. The squirrels were often seen to stretch out to their full length and roll over and wallow about in the fine powdery alkaline dust which in many places was an inch deep under the overhanging banks along the edges of the washes. Such dust baths, which were frequently indulged in with considerable evident satisfaction by the squirrels, are likely to serve in keeping the pelage of the animal clean as well as to discourage the fleas.

Our data regarding the breeding of *Ammospermophilus nelsoni* is scanty. The breeding season appears to be much earlier in this species than in the case of the Fisher Ground Squirrel in the same region.

The young of *nelsoni* are apparently all born before the last of April. None of the numerous females taken in the vicinity of Bakersfield between April 27 and May 12 were found to contain embryos. A male one-fourth grown was taken eight miles northeast of Bakersfield on May 7, 1911, and a half-grown young one was taken at McKittrick on May 18, 1911. On May 9, 1918, two immature individuals, weighing 100 and 103.3 grams, respectively, were taken at the mouth of San Emigdio Creek. These, male and female, were thus over two-thirds grown and were at this time foraging for themselves. These two youngsters were extremely playful and on several occasions they were seen to stand upon their hind legs and with their front paws braced against one another's shoulders they wrestled and pushed each other about energetically. The parents of these young squirrels had evidently cast them off to shift for themselves.

Because the California and Fisher Ground Squirrels have increased and profited by the farming activities of man in parts of the San Joaquin Valley, it has been suggested that possibly this increase has tended to crowd out *Ammospermophilus nelsoni* and therefore restrict the range of the latter (Taylor, 1916, p. 20). At the mouth of San Emigdio Creek both *nelsoni* and *fisheri* were found in numbers. Old colonies of *fisheri,* as shown by their extensive workings, were found between colonies of *nelsoni.* The Antelope Squirrels occupied the sandy washes and the areas covered by the salt-bush, while the Digger Squirrels occupied the more open tracts which were covered by a low growth of foxtail. While there must be a certain degree of competition as regards food supply between the two kinds of squirrels, this competition is probably no greater than that which exists between the Nelson Antelope Ground Squirrel and, for example, each of the two species of kangaroo rats which forage at night for similar food over the same ground used by the Nelson Squirrels in the daytime. We found no evidence, in this case, that the Digger Squirrels were driving out the Antelope Squirrels.

The badger is one of the chief enemies of the Nelson Ground Squirrel. Many squirrel burrows were found that had been dug out by this animal, and, since in their refuge burrows these squirrels have no back door of escape, capture in such cases must be more or less certain.

On May 19, 1918, a pair of Nelson Squirrels was observed to remain out in the open and watch a pair of Golden Eagles go through a series of aerial evolutions overhead, in which, with talons tightly locked together, the birds looped the loop three times. The eagles were obviously seen by the squirrels, and the swish of their wings was plainly heard by the observer, yet the squirrels were not in the least alarmed. However, when a Red-tailed Hawk flew over, the squirrels hustled at once into their holes. It was therefore inferred that the hawks and not the eagles were the active enemies of these small squirrels. Coyotes and kit foxes also dig out the squirrels in their burrows and probably pounce upon a few individuals during the daytime.

In foraging, these squirrels slip along close to the ground, often stopping in the shelter of a bush or pausing in the open and searching quietly, with body extended, for small seeds upon which they feed. On May 6, 1918, an old female which was nursing young was observed for several minutes at a distance of fifty feet. During this time the squirrel stood at her full height with body erect, busily munching a green head

of alfilaria and keeping a careful watch at the same time upon the intruder. A few days later a squirrel of this species was seen gathering dry seeds of the alfilaria. It is difficult in the field to be sure just what kind of seeds the squirrels are seeking out, since the seeds are too small to be seen at any great distance even with the aid of binoculars, and the stomach contents are so finely chewed that it is impracticable to identify the food constituents.

On one occasion an individual was seen to eat the dried flesh from the hind leg of a dead kangaroo rat. This sort of provender had been secured from a near-by meat-baited steel trap. From this incident we conclude that this species of squirrel is not altogether vegetarian in its food preferences.

Very little information is at hand regarding the food carried in the cheek-pouches of this rodent. A specimen taken at McKittrick, Kern County, on May 19, 1911, had 744 seeds of the alfilaria (*Erodium cicutarium*) in its cheek-pouches. No food stores of any kind were found in the few burrows excavated.

The Nelson Antelope Squirrel is distributed unevenly. It occurs in abundance at only a few localities. At one of these favored localities, eight miles northeast of Bakersfield, squirrels of this species were found scattered over the low hills in little colonies of six or eight individuals (H. S. Swarth, MS). It is believed that there were certain small areas here that supported at least twenty-five of the squirrels to the acre. However, they were present to this extent on only a small per cent of the total acreage inhabited. At San Emigdio Ranch ten squirrels represent the greatest number found on any one acre. At McKittrick the number per acre was thought to be not over five. Taking the entire range of the species into consideration, there is probably about one squirrel to every two acres.

Our impression is that on the east side of the San Joaquin Valley the range of this squirrel is now being rapidly restricted by farming activities. In 1911, and again in 1918, no Antelope Squirrels whatever could be found in the vicinity of the type locality, Tipton, in Tulare County, where it was common in June, 1893 (Merriam, 1893, p. 129). The first Nelson Squirrel was noted in the 1911 search thirty miles south of Tipton. The gradual settling up of the country, and the cultivation of the kind of ground inhabited by this squirrel, has resulted in the crowding out of the species over much of the eastern part of its original range. It seems only a question of time when continued reclamation will gradually restrict and eventually exterminate this species over the arable portions of the San Joaquin Valley.

The Nelson Antelope Ground Squirrel is at the present time of little or no economic importance. It inhabits barren situations, apart from cultivated land. Our opinion is that this squirrel is not likely ever to become a pest.

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## LOS BAÑOS ANTELOPE GROUND SQUIRREL.

### **Ammospermophilus nelsoni amplus** Taylor.

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**Other names.**—Nelson Ground Squirrel, part; Antelope Chipmunk, part; *Ammospermophilus nelsoni*, part.

**Field characters.**—Exactly the same as for the Nelson Antelope Ground Squirrel.

**Description.**—General coloration in all pelages exactly as in *nelsoni* proper, but clay color of upper surface a trifle paler, more buffy, and white side-stripes less distinct. Size somewhat greater, especially as regards ears.

**Measurements.**—Average and extreme measurements, in millimeters, of twenty full-grown specimens from twenty miles south of Los Baños, in western Fresno County, are as follows: Ten males: total length, 246 (234–253); tail vertebræ, 73 (66–75); hind foot, 41 (40–43); ear from crown, 7.8 (7.0–9.0); greatest length of skull, 41.8 (41.0–42.7); zygomatic breadth, 24.8 (24.0–26.2); interorbital width, 10.1 (9.4–10.4). Ten females: total length, 236 (230–243); tail vertebræ, 73 (67–78); hind foot, 40 (37–43); ear from crown, 7.7 (6.5–9.0); greatest length of skull, 41.2 (39.8–42.0); zygomatic breadth, 24.3 (23.5–25.5); interorbital width, 10.0 (9.2–10.3).

Comparison with the measurements given for *nelsoni* will show that *amplus* is decidedly larger, with especially larger ear.

**Weight.**—Only one record of adult weight is available, that of an old male, 186.3 grams (6½ ounces).

**Type locality.**—Twenty miles south of Los Baños, Merced County [really near mouth of Little Panoche Creek in Fresno County], California (Taylor, 1916, p. 15).

**Distribution.**—Known as yet only from a limited section of the floor of the San Joaquin Valley within 35 miles south of Los Baños, in southwestern Merced County and northwestern Fresno County. Life-zone, Lower Sonoran.

**Specimens examined.**—A total of 34 from the following localities in California. Merced County: Sweeney's ranch in hills "22 miles south of Los Baños," 2. Fresno County: mouth of Little Panoche Creek, 18 or 20 miles south of Los Baños, 29; Hayes Station, B. M. 502, on Panoche Creek, 19 miles southwest of Mendota, 2; one mile east of Mendota, 1.

The Los Baños Antelope Ground Squirrel very closely resembles the Nelson Squirrel, and is doubtless practically identical with that form in general habits and locality preferences. More thorough exploration will probably show that the distribution of the two is continuous, in other words that the Los Baños race has resulted from a northward extension of the ancestral stock which has allowed the acquisition of the slight differences of greater size and paler tone of coloration which characterize *amplus*.

Along the western rim of the San Joaquin Valley south of Los Baños this subspecies is common locally. The type series was taken by R. H. Beck June 20, 1912, near the mouth of Little Panoche Creek, where the animals were found occupying holes on common territory with California Ground Squirrels. In one instance a "chipmunk" was shot at the same hole with a "ground squirrel."

Near the point where Panoche Creek breaks out of the hills, a few miles farther south, the last of June, 1918, museum collectors found a few Antelope Squirrels along roads between barley fields. The cheek-pouches of the two shot at the edge of such a field were full of barley grains. The breeding season on both the above dates was long passed; young were nearly or quite full-grown. Remains of *Ammospermophilus* were found about the mouth of the burrow of a kit fox, evidence of the identity of one kind of enemy.

The sort of country inhabited by this Ground Squirrel is arid and as yet to but a small extent under cultivation. Water is not available for extensive irrigation. The economic status already set forth for the Nelson Squirrel probably also holds for the Los Baños race.

## SUMMARY OF POINTS OF SPECIAL IMPORTANCE FROM THE STANDPOINT OF GROUND SQUIRREL CONTROL.

From the foregoing account of the natural history of the ground squirrels of California the following facts and inferences stand out as seemingly of special importance in connection with the determination and application of methods of ground squirrel control.

1. Of the eighteen kinds of ground squirrels occurring within the limits of the state, there appear to be only four meriting any particular consideration from an economic standpoint. These four are the California (or Beechey), the Oregon, the Fisher and the Douglas ground squirrels, here named in the estimated order of importance (see fig. 30). All the other fourteen kinds are, for the present at least, negligible, in most of the cases because they inhabit areas not cultivated by man.

2. The Oregon Ground Squirrel is less than half the size of a "digger" squirrel, but it is ordinarily present in much greater numbers per given area within its range (most of Siskiyou, Modoc and Lassen counties) than is any one of the "digger" squirrels in its range. The Oregon inhabits open grass lands and hence comes into sharp competition with cattle interests.

3. The Oregon Ground Squirrel is more of a grass eater than a seed or grain eater, and the most successful method of poisoning should involve the selection of an appropriate bait accordingly. It does not store up food to the extent that the "digger" squirrels do. The Oregon Ground Squirrel, more than any of the "digger" category, is subject to a sharply defined period of hibernation, and this involves all the individuals, of whatever age.

4. The California Ground Squirrel is our species of greatest aggregate numbers and is the one which is most widely distributed over the cultivated parts of the state. Its close relatives, the Fisher and Douglas ground squirrels, are known along with the California as "digger" squirrels; regarding most of the following considerations the three may be classed together.

5. Because of relatively large size the individuals of the "digger" category are able to inflict serious loss. Adults average $1\frac{1}{4}$ to $1\frac{1}{2}$ pounds in weight, and are easily able to consume $\frac{1}{2}$ ounce of dry grain or 2 ounces of green forage at a meal.

6. On open range and pasture lands these squirrels feed largely on alfilaria and bur clover, two of the most valuable forage plants in the state. The squirrels are then serious competitors for subsistence against the flocks and herds upon which man depends for his own support. On cultivated ground these squirrels feed upon or destroy in other ways grain and fruit crops to a very large extent where present even in numbers not above those reached on wild land. The tendency seems to be to increase to extraordinary numbers on cultivated lands unless effectively checked by man. This is due both to improvements of food conditions from the standpoint of the squirrel, and to removal of its natural enemies by man either purposefully or thoughtlessly.

7. The food preferences of ground squirrels are strongly in evidence and vary from species to species, and sometimes within the same species, from place to place and season to season. It is common testimony of those who have practical experience in poisoning ground squirrels that the Douglas is much more easily handled than the California; in other words, the former takes the strychnine-coated barley more readily. It is obvious that the success of any method of control by the use of poison must depend importantly on the nature of the bait employed. The fact that in some places the California Ground Squirrel has been found to pass up barley altogether for the seeds of bur clover suggests a likely way of improving poisoning methods locally.

8. In the "digger" category of ground squirrels there is evidence that a greater or less proportion of the population hibernates each winter. In the Douglas this feature of the annual activity of the animal is clearly evident, in that the majority, or at the higher altitudes all, of the individuals disappear for weeks or months together during the winter season. In the case of the California Ground Squirrel, however, numerous individuals are to be seen aboveground in the lower country in favorable weather at any time during the winter. But evidence at hand goes to show that these active individuals are chiefly young of the year and that most of the older squirrels are then lying dormant belowground, in some extreme cases for as long a period as from August to February. During this interval, therefore, any method of poisoning, and probably also of gassing, will obviously be ineffective upon a portion of the population, and this portion which escapes will reappear at the beginning of the next breeding season to reinfest the area concerned.

9. Some obstacles to the success of control by the method of gassing arise through the unequal extent and irregular course of the burrows of the squirrels. It was found that although the volumetric content of the burrows of the California Ground Squirrel excavated averaged 5.2 cubic feet, in one case an extreme of 17.8 cubic feet was reached. This obtained in one of the "colonial" types of burrows in which several establishments supposed to have been originally separate had come to be intercommunicating. It was found that the usual dosage was ineffectual in this case. There is no definite way of distinguishing such "colonial" burrows, from surface appearances alone. Then, again, in some burrows there is an abrupt rise in the underground course of the burrow, which prevents the onward flow of a gas heavier than air, such as carbon bisulphid, and the squirrel is not overtaken. In either of the above circumstances we find a reason for the partial failure of extensive gassing campaigns with current methods.

10. Ground squirrels reproduce rapidly. In the California the average number of young in a litter is 7.2, with 4 and 11 as extremes. There is but one litter reared each year, and the young begin to appear aboveground about the first of May. The sexes are equally divided in a given population, and it is believed that each female breeds the first season of her life, that is, when she is slightly less than a year old, and that she has an "expectation" of rearing four more litters in case she lives to die of old age. Thus a population of 10 per acre in March may be expected to increase to 50 per acre by the last of May. Postponement of attention by the farmer is a losing proposition. A stitch in time actually saves nine.

11. The general habits of ground squirrels are such that they were able to hold their own in the face of a host of natural enemies which habitually preyed upon them before the white man's advent. The squirrels are eminently successful in the battle for existence. They inevitably prosper when any natural check is removed.

12. The recuperative powers of ground squirrels are great. It is shown that if the population of one square mile (if estimated at 640 as in the case of the California Ground Squirrel) were subjected to two successive control campaigns, each of 90 per cent effectiveness, there would still remain six squirrels; these three pairs of squirrels would theoretically at the end of the third breeding season give rise to the full normal population of 640, with a good margin for natural death. It would seem that, if absolute extermination prove not possible over any large area, eternal vigilance must be exercised to prevent the quick return of the squirrel population to the danger point. The squirrels must be looked after like weeds, which have to be dealt with year after year.

13. Ground squirrels breed upon uncultivated or waste land, from which they invade the cultivated fields within reach as well as such other lands as are not already fully populated. There is progressive emigration of a certain portion of the squirrel population each year, in August and September, involving chiefly or entirely the young of the year just coming to maturity. By a process of gradual infiltration, land once thoroughly rid of squirrels may thus be reinfested from more or less distant areas of dissemination. Lands successfully poisoned in the spring may be found repopulated the following fall from some adjoining territory.

14. Since the squirrels if not interfered with by man are stopped in their emigrations only at some natural barrier, it seems clear that control campaigns should not be limited by political or civil boundaries such as state, county, district or property lines. Rather should natural

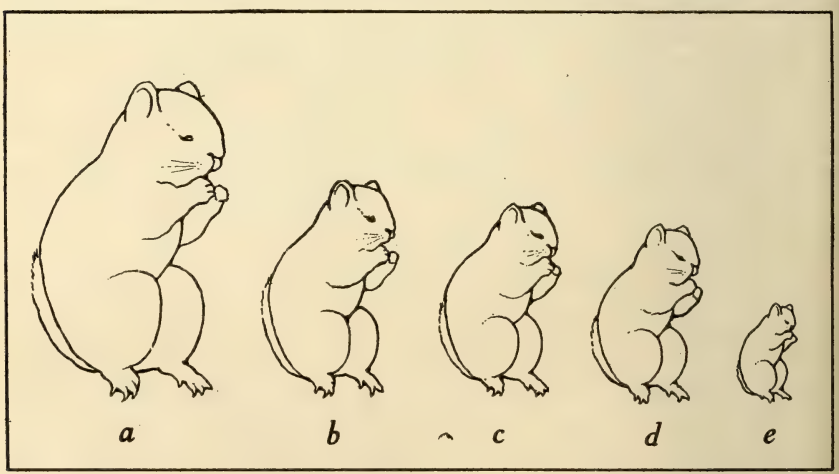


FIG. 30. Diagram showing estimated relative importance, as regards economic status, of the different species of ground squirrels in California. *a*, California (Beechey) Ground Squirrel; *b*, Oregon Ground Squirrel; *c*, Fisher Ground Squirrel; *d*, Douglas Ground Squirrel; *e*, all other species of ground squirrels in the state put together. The estimated ratios are, respectively, 10–5–4–3–1.

barriers be hewn to, such as those of climate, seacoasts, rivers, brush lands and deserts. The forest ranger in anticipating the sweep of a potential fire, or in combating any actual fire, outlines his campaign irrespective of any but those lines which will naturally aid most in stopping the spread of the conflagration.

15. If "drive weeks" be advocated, as a popular measure to secure control locally, the time of the year selected should be fixed in accordance with the optimum chances for success, on the grounds of avidity of the squirrels for kinds of bait available, minimum natural population (previously to the time of appearance of the young), and probable weather conditions.

16. The above general remarks must not be construed as in any degree intended to discourage the continued energetic application of the best methods of ground squirrel control now in use. But it is hoped the facts and inferences set forth will convince the reader that the problem is not a simple one, and cannot be solved by casual, half-hearted measures. It is believed that great improvement can be secured both in devising of method and in mode of application.

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# PROCLAMATION.

EXECUTIVE DEPARTMENT,
STATE OF CALIFORNIA.

The State Commissioner of Horticulture has instituted a campaign to destroy the ground squirrel throughout the State. It is said that these rodents do an annual damage to the amount of $30,000,000, a great part of this damage consisting in the destruction of foodstuffs, and in these times special efforts should be made to prevent such loss.

In connection with the campaign the State Commissioner of Horticulture has personally offered prizes to those schools of all classes which make the best records in killing squirrels. I heartily endorse the plan, and I hope that the efforts of those in charge of the campaign will be crowned with success, and in connection therewith I do hereby set aside the week of April 29th to May 4th as Ground Squirrel Week, and trust that during that time the school children and all other persons will do their utmost to relieve the country of the ground squirrel pest.

WILLIAM D. STEPHENS,
*Governor.*

Dated: Sacramento, April 8, 1918.

# THE COLUMBIAN GROUND SQUIRREL.

## (Citellus columbianus columbianus.)

By W. T. SHAW.

PLATE VI.

### INTRODUCTORY.

In the southeastern part of the state of Washington, in a bunch-grass plateau, called the Palouse Country, is found one of the larger species of ground squirrel, commonly known as the Columbian ground squirrel. From this region, according to Mr. E. W. Nelson, its geographic range extends as follows: "In a general way the species inhabits the Blue Mountain Plateau of northeastern Oregon and southeastern Washington and western Idaho from the Seven Devils Mountains north to Lake Pend Oreille and east of Ketcham in the Sawtooth and in Montana to the Bitter Root Valley and Helena, thence northward into Alberta and British Columbia to an unknown distance. The relationship with other species on the north has not been thoroughly worked out." It is of this species we wish to write, giving a brief but fairly comprehensive outline of its life history.

That the life cycle of this animal is most remarkable is probably due to the fact of its having lived so long under peculiar climatic conditions. Although now the territory in southeastern Washington has been turned into a great grainfield, it has not always been so; and not long ago, where wheat now waves, stretched vast rolling plains of early-maturing bunch grass. Then, by the first of July the moisture conditions were such that wild vegetation began to ripen and the squirrel, finding himself deprived of moisture obtained from the juices of plants about him, and in many cases living far from water, faced starvation or an alternative. The alternative was æstivation or summer sleep and within a month, in the midst of an ample cereal harvest, this species, so abundant in numbers, disappears entirely from the fields and is seen no more until the snows of late February are beginning to melt. This resort to æstivation, to circumvent death from thirst, passes uninterruptedly into a more profound condition of hibernation and in his restricted hibernating den he passes nearly seven months each year in a state of inactivity.

### PROBLEM.

These countless thousands of squirrels inhabiting this rich agricultural region became a very serious menace to the profitable raising of wheat, and it was decided by the Washington Agricultural Experiment Station to study the problem of the life history of this animal, hoping to obtain information upon which might be based better methods of control than those hitherto practiced. In June, 1910, such an investigation was started and has been continued with earnestness through the subsequent years. At the outset many facts of interest were noted but it soon was learned that the complete life cycle could not be obtained from squirrels in the wild state. Accordingly, extensive yards were constructed in which the animals to be studied were restricted. For convenience of reference, a general term, citellary [ci-tel′-lary] was

THE COLUMBIAN GROUND SQUIRREL. THIS SQUIRREL IS THREE YEARS OLD AND HAS REACHED COMPLETE DEVELOPMENT.

proposed to designate the yards and cabins in which the genus *Citellus* was to be studied (Fig. 31).

FIG. 31. *The Citellary,* comprising yards enclosing natural, wild squirrel dens. One of these yards is 50 by 90 feet in extent. Associated with the yards are cabins in which brooding and hibernating squirrels were studied. Here squirrels lived almost in freedom.

## THE CITELLARY.

In the construction of these yards five adjoining squirrel dens were selected. These were located on a warm sunny southwest slope, and were covered with an abundant wild vegetation of bunch grass, balsamroot and rose brush. Here fences were sunk in the ground to a depth of six feet and arranged to enclose yards of ample size (50′ by 90′ in one case). Two small cabins were constructed, one for the close study of breeding squirrels (Fig. 32) and one for the observation of those in

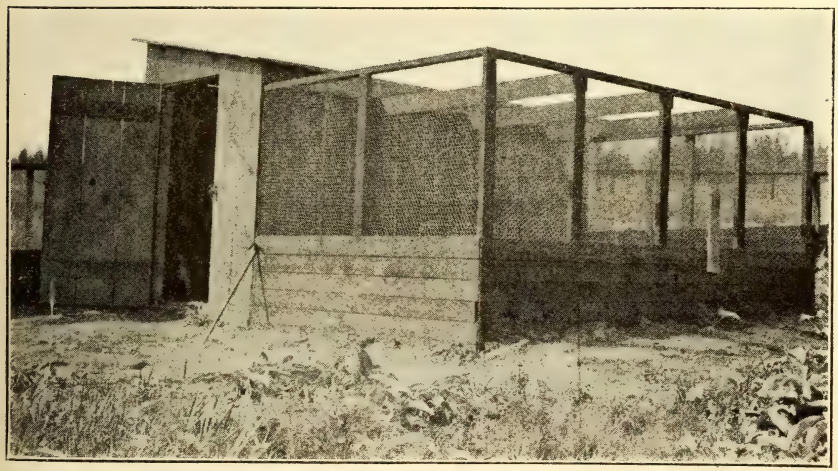

FIG. 32. *The breeding cabin.* In this building were brood nest boxes, connected with yards enclosed with wire netting. During all their confinement in these small yards, the developing squirrels could be observed by simply lifting the hinged lid to the brood-nest-box.

hibernation. In these yards wild squirrels were turned, after first having been weighed, branded, and recorded. Here they lived in semi-freedom, yet largely subject to the will of the investigator, giving to the study many facts otherwise unobtainable, verifying, too, many of the observations made in the fields. With these preparations completed, work was begun in earnest.

### ACTIVITIES.

Both in the field and in the citellary it was learned that the animals were very markedly diurnal, very responsive to sunlight and warmth, and avoided the effects of cloudy days, cold winds and wet weather. In the matter of their daily activities, they appeared about an hour after sunrise, and were all in their dens at sunset or shortly thereafter. During the day they were most abundant about 9 to 10 o'clock in the morning and avoided the intense heat of the midday sun.

### THE DEN.

A little careful observation in the field soon showed that the squirrels were living in a definite series of radiating burrows called a den (Fig. 33). These proved to be units and though long, careful examinations were carried on, in which more than 150 dens were excavated, in no case were these dens found to communicate underground. That they were visited freely by squirrels above ground, at certain seasons, was apparent from the fact that well-worn paths were observed leading from one den to another.

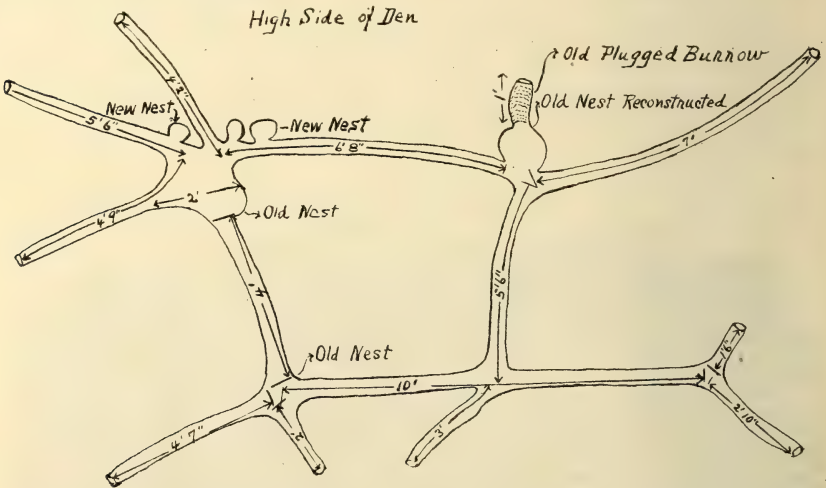


FIG. 33. *A typical squirrel den.* The total length of open burrow in this den is 63 feet 8 inches. The average depth of the burrows is 2 feet. The greatest depth is 2 feet 6 inches. The average diameter of the burrow is 3.5 inches. (From Popular Bulletin No. 99, Washington Experiment Station.)

The den itself was made of a series of radiating burrows from a common center as shown in figure 33. These burrows were about three and one-half inches in diameter except at their intersections, where they were slightly larger, and were on an average of two feet below the surface. Some burrows in deep soil were found as deep as five feet.

The nests were generally at the intersections of the burrows and were made of wild grass blades and stems and blades of grain. The brood nest was larger than the ordinary summer nest and was lined with finely shredded nest material.

### BREEDING.

Very shortly after coming from hibernation the squirrel begins to breed. The season of rutting is a very active one and is followed by a gestation period of 24 days. When the young are born they are very imperfect little animals, being naked, blind and toothless (Fig. 34). Their subsequent growth is rapid and in about five or six days they have doubled their original weight (Fig. 35). By 12 days their bodies are covered with a dark silky hair (Fig. 36) and by 17 days (Fig. 37) their eyes are beginning to open preparatory to coming out of the den

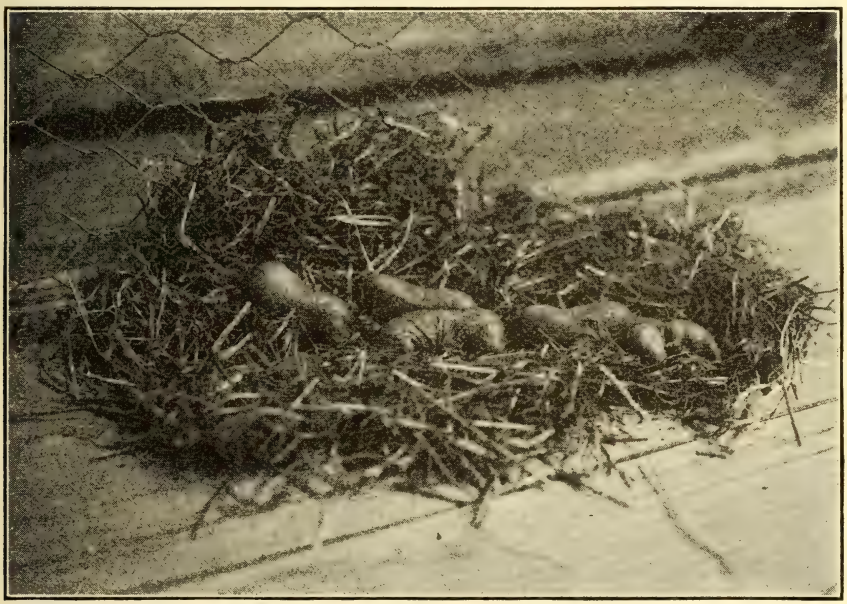

FIG. 34. *Young squirrls only a few hours old.* When born they are very imperfect, being blind, toothless, and hairless, and weigh between seven and eight grams.

into the sunlight, which they do at about 21 to 24 days. By 28 days they are out and ready to leave the brood nest and shift for themselves (Fig. 38).

At this stage in the growth of the animal, the life history seems to be influenced by climatic conditions, for already two of the five months of activity of each year has been used up and the young squirrels have to accumulate enough fat to carry them through the adverse season of æstivation and hibernation. Accordingly, growth seems to be suspended temporarily, to be taken up and completed the following spring. Figure 39 shows a wild brood in their nest. There is but one brood per year.

The seasonal breeding season is dependent especially upon the elevation; they appearing from hibernation and breeding early at low altitude (Wawawai, Washington, elevation 600 feet), and later at high altitudes (Cedar Mountains, Idaho, elevation 4,000 to 5,000 feet), although these elevations were not over 30 or 40 miles apart. What is more remarkable is the fact that on the north and south slopes of the hills about Pullman the dates for these activities varied by about seven to ten days, although the hills are not much over 300 feet in elevation

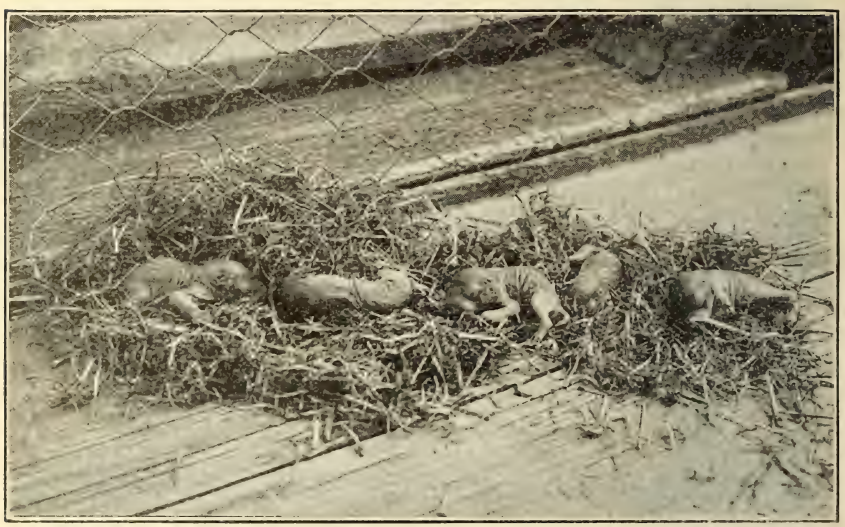

FIG. 35. *Six days old.* In the interval the squirrels shown in Figure 34 have doubled their original weight.

FIG. 36. *Twelve days old.* At this age they have become quite dark on the dorsal side owing to the developing of hair roots.

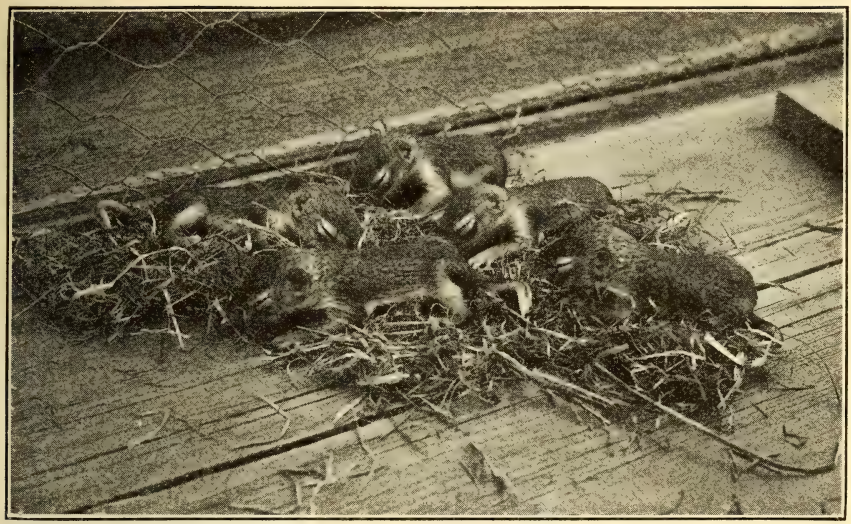

FIG. 37. *Seventeen days old.* They have now reached considerable development. Although clothed with a covering of silky hair, and otherwise fairly well developed, they still are blind. At this time a twitching commences over the eyes, which, in the course of two or three days, results in opening the eyelids. They are then ready for active life above ground.

above the intervening draws. This rapidity of growth, together with the correspondingly rapid plant development, has undoubtedly produced an influence upon the food habits of the animal.

## FOOD.

It has been a point of common observation and note by many naturalists that the Columbia ground squirrel is one of the most vege-

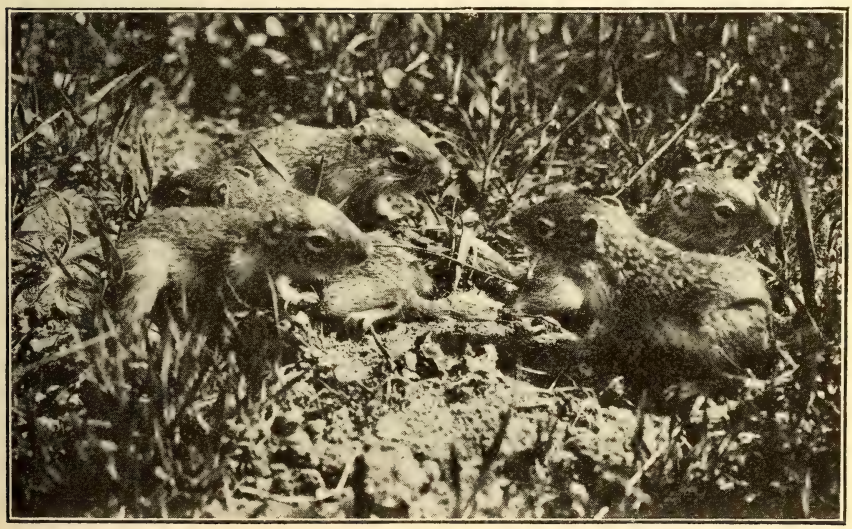

FIG. 38. *Twenty-eight days old.* These are the same squirrels as shown in Figures 34–37. They are now ready to shift for themselves.

tarian of all the ground squirrels. With the opening of the season the squirrel lives largely upon green succulent vegetation. This diet continues through the season of active plant growth. When the vegetation begins to ripen his attention is turned to the more fat-producing seed products of grain and plants, and by the time for the beginning of æstivation the animal has become enormously fat.

Like many other rodents, an occasional feast of flesh appears to be necessary even though it be secured by cannibalistic methods.

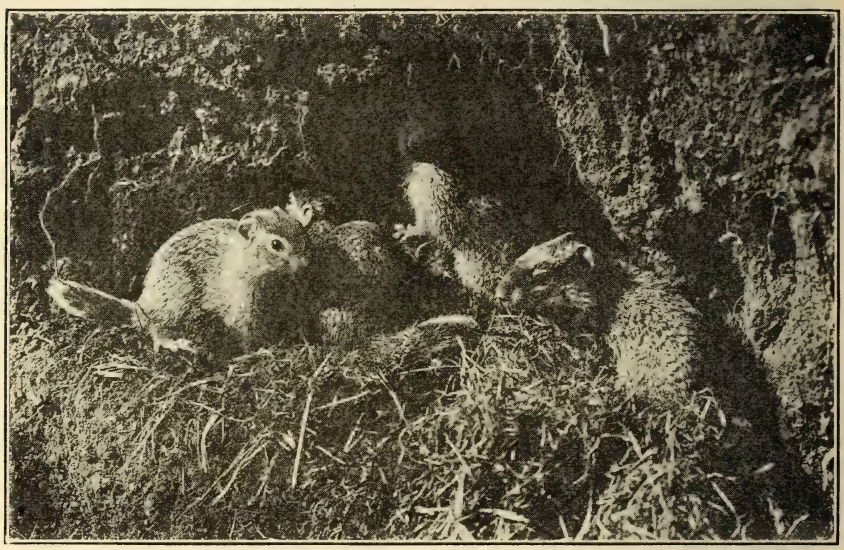

FIG. 39. *A brood of young, wild squirrels.* The average brood for this species is five. This picture represents a vertical section showing the brood nest which is made of wild grass or grain straw and lined with finely shredded material of the same kind.

Stomach analysis made during these investigations from squirrels shot in the fields at various times of the day and different vegetation habitats and state geographic ranges show the following conditions:

Of 43 stomachs examined, 100 per cent contained vegetable matter; 86 per cent contained vegetable matter entirely; 2 per cent contained traces of mammals; 13.9 per cent contained traces of insect remains.

### ÆSTIVATION AND HIBERNATION.

In the preparation of this long period of inactivity, the squirrel has become enormously fat. Not only has he stored up enough of this fat reserve to carry him through his long night of seclusion and darkness, but past it, and the adverse conditions of spring, and well on into the breeding season.

As the season of green vegetation gives way to one of parched dessication, he instinctively seeks a place of seclusion, becomes timid and shy, and is seen only occasionally during the last two weeks of his activity. He avoids prolonged exposure to noonday heat, which is fatal to him now. He sleeps long intervals at a time, partakes very sparingly of food, and when his alimentary tract is largely free from

FIG. 40. *Vertical section of a hibernation den.* This den has been opened for spring. The exit shaft leads from A, the exit, to B. The cell with the nest is shown at C. D represents the drain, at B is a temporary plug placed in the exit shaft by the squirrel to shut out the cold during the night.

food residue, passes into that very remarkable and profound deathlike condition of æstivation and hibernation.

The securing of data upon hibernation is one of the most arduous tasks facing the investigator. Frequently the hibernating den (Fig. 40) is remote from any surface indication of its presence, and although it is in most cases associated with a summer den, is so completely and thoroughly plugged off from it as to be very difficult to find. It appears to be made in this way: A burrow is run out from a summer den and a perfectly circular cell is excavated for the reception of the hibernating nest. Often a shaft is started towards the surface of the ground for exit in the spring. This shaft is not completed until winter is past and the squirrel ready to come from hibernation

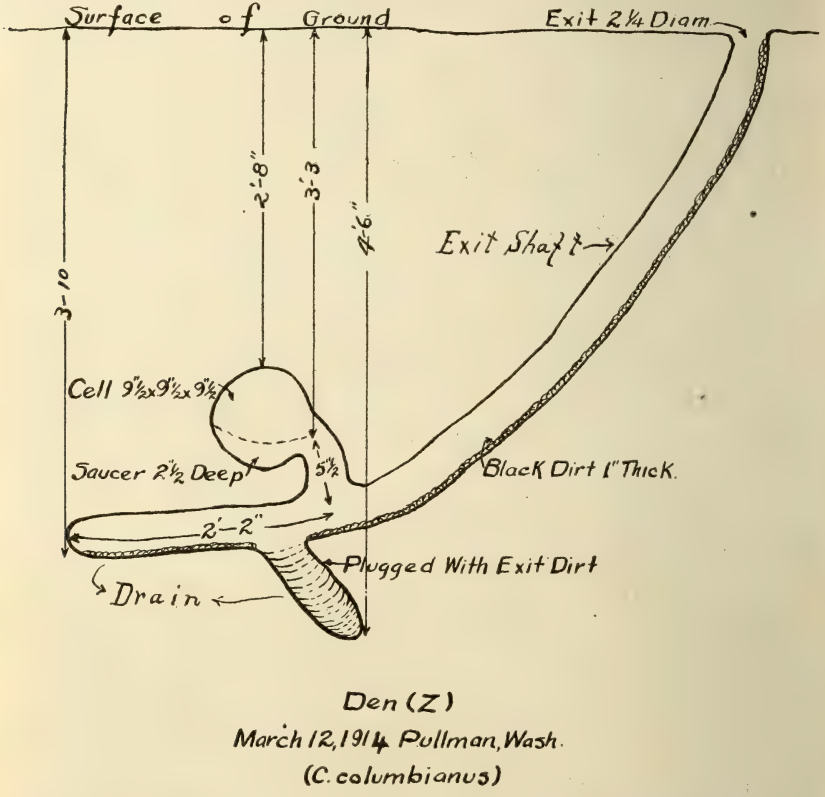


FIG. 41. *Sectional view of a hibernation den.* When the den is opened for spring the earth taken in making the exit shaft is spread along the bottom of the shaft and dumped into the drain.

(Fig. 41). Having the cell completed the nest is placed in position, coarse grass on the outside and very finely shredded material in the center, completely filling the cavity. As a last resort the squirrel plugs himself in by digging a drain under the nest and using the dirt taken from this drain to close the entrance to his hibernating den (Fig. 40, D). Thus all connection with the exterior is closed by this earth being firmly tamped into place by the nose of the animal.

FIG. 42. *A hibernating squirrel in position in a hibernation nest (Vertical Section).* They curl very tightly in a vertical position.

Having retired from active life, he sits down on his sacrum, curls up *vertically,* so tightly that the air is quite driven out of his lungs and in the course of a few hours has passed into a profound comatose condition accompanied by a very low temperature, a very weak heart

FIG. 43. *An exit.* After the long period of æstivation the squirrel digs from his secluded den through to the surface, making a small nest hold which is not easily detected by the enemy and through which little storm can pass.

beat, and a scarcely perceptible respiration (Fig. 42). Here he remains for days at a time, in what seems to us a condition bordering life and death, yet normal, for seldom does one fail to come out of it. In the spring following he completes his excavation to the surface (Fig. 43) and is ready for active life again.

In the citellary excellent opportunity was given for observing the phenomena of hiberation. Here in a small cellar they were kept and here examined from day to day, weighed and photographed at the will of the observer without even being disturbed from their repose. It was found, among other things, that they did not maintain a continuous comatose condition but awoke for a few hours at intervals of a couple of weeks. The reason for this and many other curious phenomena will be discussed at length in the complete account of this life history study to be published in the near future by the Washington Experiment Station. It was also noted that the animals were losing very gradually in weight from day to day, although they were in a state of almost perfect inactivity.

For more than three years this work of searching for, and investigating hibernating dens was pursued, through torrid heat and dust of a late summer day, or the biting frost of a wind-driven snowstorm. Many were the short dark days of winter disappointment—but wonderful those rare days of discovery and opportune for camera and sketchbook, when successful search revealed a hibernating squirrel.

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Herbert Hoover, United States Food Administrator, indorsed the state-wide campaign of California in the following telegram to the State Commissioner of Horticulture:

WASHINGTON, D. C., April 9, 1918.

GEO. H. HECKE,

*Commissioner of Horticulture,*
*Sacramento, Cal.*

Understand you are undertaking campaign for the eradication of ground squirrels in California. This has my hearty approval as these squirrels destroy vast quantities of food which might otherwise be used for support of our armies abroad and the allies. The school children should be of great assistance in this campaign and the knowledge that they are doing a patriotic duty should stimulate them to their utmost efforts.

HERBERT HOOVER,
*United States Food Administrator.*

## A HISTORY OF GROUND SQUIRREL CONTROL IN CALIFORNIA.

By W. C. JACOBSEN.

### INTRODUCTION.

The control of ground squirrels has held a prominent position in the economic welfare of California from very early days. It is, indeed, fascinating to go into the past history of our state but a few short years to learn of times when this destructive pest was considered quite a necessary fixture, as essential a part of a biological whole as was anything living here at the time. As decade succeeded decade it became apparent that, rather than justifying a position chargeable to profit on our economic scale, the operations of the ground squirrel and many of his companions more and more assumed the form of a loss. Instead

FIG. 44. Automobile load of five hundred and fifteen poisoned squirrels from two hundred acres. Poison was placed in the morning and at noon the load was gathered.

of an asset, as the squirrel was to the Indian, he became a liability for those who took up the art of making the soil produce the wherewithal to exist according to more modern and civilized standards. Presumably, this has all followed as the natural order of things which, to a limited degree is true, but we assume it has resulted more or less from an artificial cause for which the white race must assume the greater blame. Species for whom nature cared in the past we now have as an unwholesome charge for ourselves. Natural control methods at one time seemed to be effective; at least in so far as evidences that are now available would indicate. Let us take some small distant areas, for those are all we have remaining where conditions might be called primitive and where we do not find a superabundance of ground squirrels, at least

not in numbers to warrant alarm. Natural enemies in so far as they have persisted in these isolated spots seem to fare as before, but as a rule for most of the state, natural control has passed. We gradually find either more use for the natural enemy or a place of condemnation for him so that the life of these assistants to our cause has been and continues to be seriously jeopardized.

When California was regarded as a land of riches by the Spaniards it was also looked upon as a place to procure rare and valuable furs. This period marked the inception of an unending slaughter of predatory animals by the Russians and by the representatives of the Hudson Bay Company. It is true, however, that they did not make quite the serious inroads upon them in California as had been the case farther north for as they penetrated the south fewer prime furs were to be obtained. Further, it was not long before the value of range lands, resulting in the establishment of a stock growing industry of enormous proportions for California, was realized. In cattle and sheep the ground squirrel found a more formidable competitor for natural forage than the deer had been and, together with the depredations of natural enemies, a lack of food might spell their extermination. But, on the other hand, stock growers found the predatory animals a source of great annoyance and plans were consummated for the destruction of these animals which resulted in serious diminution of their numbers in a remarkably short time. Before going into the struggles of the settlers in combating rodent pests, let us turn to the early mention of ground squirrels. Except for Indian legends, of which there are many, the first information necessarily must come from the European voyageurs.

When Sir Francis Drake made his visit to the coast of California in search of wealth, he and his companions noted the wild life which abounded. Mention is made of deer that were seen "in herds," and he mentions "a kind of cony" observed running about. After this fashion his observations are stated: "And besides a multitude of a strange kinde of Conies by farre exceeding them (the deer) in number; their heads and bodies in which they resemble other Conies; are but small; his tayle like the tayle of a Rat, exceeding long; and his feet like the pawes of a Want or Moale; under his chinne, on either side he hath a bagge, into which he gathereth his meate when he hath filled his belly abroade that he may with it either feed his young or feed himselfe when he lists not to travaile from his burrough; the people eat their bodies, and make great account of thier skinnes, for their kings hollidaies coate was made of them." This interesting account shows that the ground squirrel has long served as an article of food as well as a means of protecting the body.

In another narrative concerning the same voyage we find the following note: "We found the whole country to bee a warren of a strange kinde of Conies, their bodyes in bignes as be the Barbary Conies, their heads as the heads of ours, the feet of a Want, and the taile of a rat being of great length; under the chinne on either side a bagge," etc. The narrators in either case were not naturalists, consequently we must wait until a later date for the scientific description of the species that have caused so much damage in California. We can, however, gather sufficient suggestions from these words to assure ourselves that the

ground squirrel received due recognition early in the history of the state, since the year of Drake's voyage to the California coast was 1579. Hernandez, a Spanish scientist, describes many species of plants and mammals in a ponderous treatise written in Latin and edited in 1651, but so far as can be ascertained the catalogue confined itself to species south of the present Mexican border. In 1829, John Richardson, who accompanied Captain Beechey on his famous voyage to the Pacific, prepared the first scientific description of which mention is made in the natural history of the California ground squirrel in this issue.

DESPAIR.

SUCCESS.

HOW IS IT, NEIGHBOR?

FIG. 45. An early advertisement advocating the use of carbon disulphid by the funnel and hose method.

## EARLY HISTORY.

Gradually the mission fathers moved northward from Mexico, founding the monuments to their activities which are left standing even now from San Diego to San Francisco Bay region, and it is from the archives, the records, and statistics of these worthy men that we again hear of the ground squirrel. That this particular rodent formed a considerable part of the natives' diet we have very little data except for occasional statements by residents of missions or voyagers by sea. As for those coming from Spain and Mexico depending upon squirrels at all for food, we have no definite information. We do learn of Indians bringing squirrels to the newcomers, for in 1773, shortly after the establishment of the Mission San Antonio, Indians brought squirrels in to the missionaries along with pine nuts, acorns and rabbits. It would seem that where food was not altogether plentiful ground squirrels might have been eaten extensively.

With Spanish occupation came the practice of agriculture in its many phases. The methods practiced were crude and the Indians unskilled, nevertheless crops brought forth a harvest which, barring climatic influences and pests, increased in size annually. Dry years and floods came from time to time. Usually a dry year brought pests in far greater numbers than normally was the case, since their natural food could not be obtained in the required amounts. "Locusts," as

the grasshoppers were called, "ratones" or rats and "ardillos" or squirrels came in for the greatest share of complaints. Not all of the missions suffered as severely as did those in the Los Angeles, Ventura, Santa Barbara, San Luis Obispo, and Monterey districts. The regions mentioned have been noted for years for the large numbers of squirrels and it was here, too, that the most flourishing of the missions were to be found. The same rule applied in that day as now. Localities had their range stock to protect against the ravages of predatory animals, and breaking the soil entailed the destruction of cover for the lesser enemies, such as snakes and predatory birds, but it produced a new foraging ground for the squirrel; his food supply was more readily obtainable, his efficiency had to be increased only to guard against the foe, and more time could be devoted to this in view of the lesser effort necessary in seeking food. Not only were facilities for obtaining food bettered, but a variety of products was forthcoming, spreading over a greater period of time in the year. Range stock were beginning to compete for natural food, which to a limited degree forced a seeking for more suitable fields from which to garner a harvest.

FIG. 46. County Horticultural Commissioner weighing out poisoned grain at central mixing depot preparatory to distributing it to centers throughout the county.

Another enemy who softened in his persecutions was the Indian. If we can take the statisticians and historians of the missions at their word, we learn that crops raised at the missions, range and domestic stock, furnished a new and plenteous food for the Indian just as did the newly cultivated fields for the ground squirrel. Indians no longer hunted them extensively for food and presumably this was true in so far as the utilization of their hides for bodily protection was concerned. Hides of domestic stock and the newer types of cloth served the purpose more satisfactorily.

As community life became more and more an essential part of the mission, centers of population called for increasing the agricultural production. Truly everything that detracted from harvesting the limit would be observed, hence the ravages of pests were considered in due time. The ending of the eighteenth and beginning of the nineteenth centuries bring specific mention of damage done, which, however, appeared to be largely local. No mention is made of any very widespread destruction of crops. It seems that rats were prevalent, for space is taken at times to mention the "ratones" which worked on the harvested crops. These references may be to woodrats or may have been a collective term to designate all rodents, including the squirrels and field mice.

Naturally, the first active ground squirrel campaign, the first symptoms of concerted and unified effort to effect a riddance of the pest will evoke some interest. From all that can be gathered, this occurred at Santa Barbara during the spring of 1808. The historian Bancroft, speaks of it in this fashion: "That ground squirrels had already proved a pest to the farmer at this early date is shown by the fact that about a thousands of these animals were killed in nine days of May, 1808." No clue as to the methods of control employed is given, but judging from the rapidity with which the deal was consummated, bows and arrows must have played a large part. We do have evidence that poisons were used on rats at San Diego when they became a pest, and it may be inferred that poison may have been used against squirrels.

The years 1821 and 1822 seemed favorable for ground squirrel multiplication, inasmuch as the Purissima and the Santa Margarita Rancho of San Luis Obispo Mission registered complaints. Both are in typically good squirrel country so the report necessarily need not be surprising. Later, in 1829, it is found that throughout California where missions had been established both squirrels and grasshoppers did considerable damage. The fact that they were troublesome can in a measure be accounted for in the dryness of the season. Lack of natural food has forced the squirrel to seek fields anew for foraging, especially as range stock became more numerous and wild horses were getting to be very common as well. Again, in 1839, considerable damage by squirrels is noted in the neighborhood of San Buenaventura.

By this time some enterprising Americans and Europeans had come to the Pacific coast, few in numbers at first but increasing annually. During the "40's" when the land-grant system held sway, when the land of our state was considered to be fit for naught but grazing, complaints necessarily would be few. The large holders have never had cause to worry about the damage by squirrels for it meant merely the loss of feed for a few head of stock out of thousands. The loss in this way would be less, perhaps, than the direct loss to stock from the number of predatory animals which helped to keep squirrels in check. It has ever been noticeable that the trouble and damage complained of has come from agricultural communities where many people are fighting against the adversities of climate and pests on small tracts under not altogether favorable conditions; where every cent expended for material or labor must be conserved in order that a profit may be realized at harvest. In counties where large holdings are still the rule, a very

indifferent attitude prevails, except in the instances of the homesteader or small purchaser adjacent to the rancho.

Emigration from the east brought American ideas, customs and traditions to California with the result naturally to be anticipated that the attitude of the Mexican, or the native Californian, would be unfavorable. The refusal of all rights to Ameircans, and even expulsion was contemplated, which, if attempted, would have ended disastrously for the Mexicans. The war made possible the establishment of California as a military possession in 1846, after the short period of the Bear Republic, independently established by a group of zealous United States soldiers. It is interest in items such as these that absorbed the attention of all. The more peaceful pursuits would pass unnoticed and historians were generally impressed with the greater activities of the grant holders than with the small owners from whom complaints were likely to come.

During one period of California's existence, perhaps its most important historically, we may be quite assured that rodents played a minor role in public interest. This was the gold discovery period. Everyone dropped his occupation, whether he be shopkeeper, banker, agriculturist or seaman; to make a "strike" was uppermost in the minds of all. Many of the large owners saw a demoralizing effect upon the labor situation as far as their agricultural interests were concerned, for these grantees generally had a retinue of herders and general farm hands, in many instances totaling a thousand or more. It meant that from the grant farthermost north at Cottonwood, to the southernmost in San Diego County, the gold rush would carry practically all away to the wealth-yielding fields of east central California. Those that farmed their acres, who were not lured by the possibility of instantaneous riches, in many cases made far greater fortunes by supplying the many towns of mushroom growth with provisions raised upon near-by lands.

Some notice had to be taken of rodents by the gold diggers and an occasional grievance is recorded where squirrels and gophers attracted by the vegetation produced by the water carried along the ditches, undermined the walls of these ditches, causing a break, with consequent turning off of the water. One specific instance in mind was recorded by the Sacramento *Union* of June 11, 1860, in which case 30 feet of ditch bank of the Tuolumne County Water Company washed away due to rodent borings, to such an extent that the water supply for a thousand miners about Columbia was effectually cut off, entailing a considerable loss of time and labor.

The influx of people from the States, and in fact from all quarters of the globe, brought a decided surplus of laborers which, together with those desiring to remain after the main gold rush, gave an excess of workmen over and above the demands of the gold diggings. Some of these were bound to become farmers. In the meantime it had been conclusively demonstrated that California lands were of value for things agricultural other than grazing. Many had advanced experimental crop growing and the possibilities with irrigation were beginning to be realized. Vast valley acreages spread north and south from Sacramento, but who owned them? A long period intervened during which the titles and ownerships had to be proven. The work of the courts

and land commissions was slow, many fraudulent claims and titles were unearthed. In spite of these delays agriculture and horticulture began to flourish.

## FIRST LEGAL EXPEDIENTS.

Contra Costa and Alameda counties from earliest times seemed to forward complaints of farmers against ground squirrels quite regularly, and the residents in these counties prevailed upon legislators and supervisors for legal action before anything of note was done elsewhere. Land titles gradually had been settled, thriving agricultural communities were becoming numerous, so that with the arrival of the decade, 1860–70, we find the records of rodent damage to be no mean items.

The demands for legal expedients to relieve the situation prevailing from these enormous numbers of squirrels became more numerous and discussions arose which brought out ideas of many sorts as to the most suitable laws or ordinances. It was generally agreed that nothing short of compulsion would do. Some few, however, could see remarkable results by payment of bounties. One amusing reference is made to a ruling which should impose upon a neglectful landowner a fine based on the acreage of his land, which fine would be collected upon the expiration of 30 days, but if no action was taken a second period was allotted at the expiration of which the initial fine was doubled and trebled with a corresponding third failure and so on. While the penalty would not be too severe for the first offense, still the remedy offered here could in no way reach the nonresident owner. The neighbor's squirrels were already complained of: "'Twas ever thus."

FIG. 47. Reconnaisance crew investigating rodent infestation upon state lands preparatory to conducting eradicative measures.

The state legislature of 1869–70 was the first to recognize the need for action and this time it came in the form of a bounty law, applicable to certain of the counties where damage had at this early time proved to be most severe. Not only did California have bounty laws, but many states east of the Rockies which were troubled with prairie dogs and squirrels had enacted similar legislative measures. The bounty plan held sway in California for a considerable period until superseded by the ordinance-inspector plan. Years of exceptionally heavy depre-

dations revived the "bounty scheme" even as late as 1917. The bounty law of 1869–70[1] provided for proper assessment to be levied upon taxable property for the establishment of the so-called bounty fund. The amount assessable for this fund varied with counties. Contra Costa County had the highest assessable amount, due probably to the excessive number of squirrels within its boundaries. Five cents per $100.00 valuation in Contra Costa and two cents in each of the following counties: Alameda, Stanislaus, Merced, Fresno, San Joaquin and Yolo. It was necessary to have 50 squirrel scalps or 25 gopher scalps before any claims for bounties on these animals could be filed. The total amount payable in any one county depended, then, upon the amount levied into the bounty fund. The regulation bounty for the period was five cents for squirrels and eight cents for gophers. There can be no question about the satisfaction that prevailed as soon as these laws became effective, but who could tell that these laws might not be declared unconstittuional? However, no one questioned their legality as statutes, at least for the earlier period of their existence, for they were amended a number of times by the legislature of 1871–72.

Alameda County went a step farther in getting bounty districts established by the board of supervisors,[2] when a petition defining the limits, accompanied by names of five-eighths of landowners within a certain district should be presented to the board asking for establishment of such districts. The board of supervisors could set the amount of the bounty to be paid and were authorized to assess at a rate not to exceed five cents per $100.00 taxable valuation, in the particular district. During this same session Contra Costa County lost her bounty law by legislative act,[3] the exact cause for which can not be ascertained.

However, considerable evidence has been produced to show that during the following year, 1873, ravages of ground squirrels caused a multitude of complaints from the bay counties, and not in the least from Contra Costa. Small farms, dairies and orchards abounded in the east bay region, consequently it would seem most probable that from this quarter the interest to institute new methods and to try them out both from the angle of control and legislation would exceed that in counties where large ranches were still the rule. And true enough, later we find a convention called to meet in San Francisco to discuss ways and means, in which Contra Costa and Alameda counties played a most important part. This convention carried the bounty system into the district inspector system, which will be dealt with after having followed the successes and failures of the bounty.

## BOUNTIES.

The statement already was made that not a corporation or enterprise in the state of California paid dividends as large as those that farmers would realize from the few dollars properly employed in exterminating ground squirrels.

It would seem that if professional squirrel hunters or poisoners could be encouraged, at least temporary relief could be looked for, but it

[1]Statutes of California 1869–70, Chap. CCXIV, p. 316.
[2]Statutes of California 1871–2, Chap. CCCXVII.
[3]Statutes of California 1871–2, Chap. DLXIX, p. 834.

soon became apparent that men engaged in this sort of work would far rather contract on an acreage basis. Bounties did not seem to be particularly attractive to the hunter nor even to the counties themselves. As a matter of fact the many counties had the state bounty law repealed during the legislative sessions of 1872–73–74–75–76 and 1877. The law had proved to be inoperative. The only way in which bounties again came into force was through the enactment of laws empowering boards of supervisors to provide for the destruction of ground squirrels,[1] gophers, etc. No particular means were specified, hence the methods placed in effect were at the discretion of the board. From time to time, infestations of ground squirrels would become heavy in certain valleys or districts in a county, resulting in the establishment of the bounty scheme. A great many records of amounts paid out in this fashion have come to light, but with no particular sequence, for a period of bounty payments either soon created a deficit in the bounty fund or caused such an enormous drain on the general fund that the board of supervisors was forced to discontinue same. Whenever these county officials were petitioned to reinstate the bounty plan or whenever they considered the damage serious enough, they would discuss it through one or more meetings before final action would be taken. It is quite evident that supervisors had no well-defined idea as to the number of squirrels existing at any one time in their county, for a high bounty would be instituted which had to be discontinued in a few months, due to depletion of funds set aside for the purpose.

Notation should be made of some of the amounts paid for bounties through the years and the enormous expense it has occasioned can in some measure be judged thereby. Whether it was ever a profitable proposition for the farmer or the country at large to pay large sums for squirrel bounties, is greatly doubted, although this concession is made by one writer that the burden of extermination through bounty payments falls as heavily upon the shirking landowner as upon the energetic one. The large landholder also had a share of the expense to stand if the small rancher was forced to exterminate the pest on part of the larger holdings in order to protect his crop.

In 1892 one party from Bradley turned into the Monterey Board of Supervisors squirrel tails to the number of 21,755, claiming $1,085.37. This was a part of 36,000 passed. In San Benito County at the meeting of the Board of Supervisors claims were paid on 105,200 squirrels and gophers, chiefly the former, which made a total for the spring and early summer of 225,200 of these pests at five cents each. The argument is put forth by the Hollister *Advance* that if each of those squirrels had done a dollar's damage the business was profitable, even though it seemed an enormous drain on the treasury. In June, 1899, the board of San Luis Obispo paid to one man a two-cent bounty on 15,434 squirrels, and during April, 1900, the Monterey County supervisors allowed claims for 83,452 tails for the spring season. During the years 1913 and 1914 the Modoc County Board of Supervisors paid out $14,761.57, which at three cents per tail would amount to nearly a half million squirrels, mostly Oregon ground squirrels, which are no mean destroyers of agricultural products.

[1] Statutes of California 1883, Chap. LXXV, sec. 25, par. 28, p. 308.

None of these items show any continuous expenditures but are merely examples of years or parts of years. This went on spasmodically from 1869 until 1917, a period of almost fifty years. While no doubt millions of squirrels were killed and millions of dollars saved, still one, viewing California from an infestation angle during the spring and early summer of 1917, surely would be convinced of the absolute failure of bounties.

The bounty laws were deficient in many respects. Whenever a price is set upon the head of a ground squirrel there must be a goodly supply of rodents in order to make the killing of them attractive from a remunerative standpoint; otherwise the amount of the bounty must be high enough to compensate for lack of numbers. This will lead to a lack of uniformity in bounties in adjacent counties which in turn is conducive to fraudulent claims. Unless the state of California would be in a position to pay a state-wide bounty, slight possibility would appear for the inauguration of uniform payment of bounty claims among the counties. Bounties were collected in counties where the squirrels were not even killed; one county would demand the tails and another the scalp, in which case two counties might pay the bill. An experience in one of the northern counties where the Oregon ground

FIG. 48. Burrow of Oregon ground squirrel, through a depth of snow. Lack of food makes this a favorable time to institute control measures; however, climatic conditions makes it impractical.

squirrel exists might be cited: Indians employed to irrigate alfalfa fields, coming upon half-drowned or weakened squirrels, would turn all females loose on dry ground, after having cut off the tail, in order that bounty breeders might not be entirely exterminated. Further, many of the squaws had become proficient in making more than one tail from the hide of a squirrel by taking the hide from the back, and wrapping a cut portion of it about a small stick. The stubby tail of this particular species could be quite well imitated. Without the persistent application of the bounty for a long continued period of years,

the bounty plan has proved itself a hopeless source of relief. No county in California can say that an approximate control has ever been reached; nor has any county continued payment for several years at a time under the bounty scheme of extermination. Owing to the lack of concerted effort on the part of landowners, or on the part of bounty hunters, of which there were a number of professionals, the amounts expended were really wasted, for reinfestation was rapid.

### SUBSTITUTES FOR BOUNTIES.

After it had been so frequently demonstrated that bounties were inefficient and inadequate, boards of supervisors naturally looked for a means whereby they could carry out the part of a law entrusted to them.[1] The plan of free poison not only seemed to point toward a solution of ground squirrel eradication, but opened an opportunity for political patronage to many of their constituents rather than to a few. The Tulare County Board of Supervisors in 1902 allotted to each supervisor the sum of $500 to be used in making up poisoned grain for his district. This county merely serves as an example of the change, for many others tried the plan but discontinued it after it was learned that many a pound taken was never used for squirrels at all. Often it was placed on a shelf or suspended from a rafter to remain for several years. Often it was found to make fairly suitable seed grain if supplied in large enough quantity and when found to be comparatively ineffective against ground squirrels served as chicken feed when mixed with other unpoisoned grain. One plan adopted by the Modoc County Board of Supervisors did away with a great deal of misuse of the free poison privilege. Most ranchers in that county raise sufficient oats for horse feed, consequently it was quite feasible to follow a suggestion to furnish the ingredients necessary to making a good preparation in a form ready to apply to the grain. This was started in the spring of 1915, following the payment of $9,159.62 on squirrel tails at three cents apiece in 1914.

Preparation of the ingredients in this way proved very satisfactory. The fluid was mixed fresh each week, consequently no cause for ineffectiveness could be charged to the preparator of the dope. If anything was wrong with the poisoned grain the one mixing the grain would generally be found to blame. It might be noted that the individual compounding this fluid could be dishonest, since a ready market could be found for the ingredients; however, it would soon tell in the rate of mortality among the squirrels per quart of grain. This method was pursued even during 1918 with an expenditure for this year of $6,308.03 for necessary ingredients to make the paste to be applied to the grain.

With the advent of the County Horticultural Commissioners Act of 1917 it was very obvious that some expedient would need to be adopted whereby poisoned grain or supplies for properly mixing a suitable product should be furnished by county horticultural commissioners. At the County Horticultural Commissioners' Convention at Sacramento during November, 1917, the plan suggested and already adopted by many commissioners, namely, to furnish poisoned grain mixed according to the best known formula at actual cost, was generally

[1]See footnote, p. 729.

endorsed. Strychnine, saccharine and glycerin were to be purchased in large quantities at wholesale price, thereby giving users of the product a reduction in price amounting to a considerable sum for the counties where the practice was followed. When a rancher must pay for what he uses it is reasonable to believe that proper disposal of the article will be made. This seems to be the only logical outcome of any plan whereby the county desiring to assist in relieving the situation can supplant the bounty or free poison system.

What methods of control were in use at this time will follow, after going back to some of the earlier methods in vogue.

### EARLY CONTROL.

In the earliest recorded campaign at Santa Barbara nothing certain is known of the methods used, and naturally we must wait until information on methods is recorded in suitable form before we can gain clues as to methods prevalent in early days. Drowning was practiced wherever irrigation had been taken up, but its use against squirrels was noted to be far less effective than on gophers. With the assistance of dogs many could be killed wherever land could be flooded. In 1861–62 a natural drowning occurred in parts of California due to the exceptionally wet winter. In sandy lands some went to the trouble of heaping a pile of dry sand over each burrow so that when the occupant should try to dig out he would find sand behind him as well as before him so packed as to suffocate him. This idea is reputed to have come from the Indians, but was used in a number of instances by intelligent landowners at a later date.

It was noted that during dry years squirrels would flock to places where vegetation abounded, or close to stream banks. The not uncommon fallacy of today was extremely prevalent in early times, that squirrels dug to water and during an excessively dry year the water table or soil moisture of which the squirrels availed themselves receded to such an extent that a new source of water must be sought. These observations led to the idea of using poisoned water during a dry year, which truly has proven efficacious in many localities. In 1866 we hear of a peculiar report of damage in a cemetery at San Jose, where the graves were being dug into and contents strewn about by squirrels. The expedient used to dispatch the marauders by the observing caretaker was water poisoned with strychnine. Notice having been taken of the habit of drinking water out of cans after a rain, he supplied fresh water for several days, then substituted poisoned water, after which procedure the squirrels ceased to be a source of care.

The technique of sound control measures was beginning to come to the fore in the late '60s and early '70s. Many homemade remedies and expedients that suggested themselves from experiences with rodent pests of various kinds in former locations were placed in the farm journals mainly to lend assistance to those just starting to farm or to those whose experiences with rodent pests had been limited. Prior to this time, agricultural journals had found more space for the pocket gopher, seemingly because of his presence in garden plots and backyard orchards. Foolish systems of operation were put forth as well as many that were not applicable to California digger squirrels. Many

settlers had pushed westward with the coming of the railroad from the plains area where species different from ours were indigenous; or from eastern states where rodents of the ground squirrel and pocket gopher type were unknown. It was an entirely new problem for them; hence, it could well be expected that information was eagerly sought and in many cases advice was profusely given though often not of an altogether reliable nature. Startling statements were made as to the fecundity of the ground squirrels. Many were quite certain that more were being killed each year as a result of vigorous attacks of the husbandmen than existed at any one time. Litters were born, according to several observers, at least two or three times annually, for in no other way could the great horde present at all times be accounted for. That "squirrels bred like rats" was not at all an uncommon expression, and it persisted until well into the twentieth century. An early means of combatting the pest was to rely upon the efficacy of merely plowing the land, presuming for the most part that the disturbance of the soil surface would at least rid cultivated fields and thereby preclude the possibility of damage to annual crops or to cultivated orchards. This proved to be no deliverance, for the stockgrower whose acreages were beginning to be encroached upon by intensively farmed tracts and whose herds met fences springing up on all sides realized less feed for his stock, consequently the squirrel who knew no fence did not hesitate to move. While the damage done to forage crops of the range was perhaps not excessive, nevertheless the presence of ground squirrels evoked comment as to the possibility of their reducing range value.

### POSSIBLE VALUE OF SQUIRRELS.

Then, as now, there were those who assured themselves that ground squirrels could not be wholly without value; there must be something for which they might be utilized. They were placed upon this earth for a purpose. Why not as food—some of the more enterprising asked, or could not the hides be turned into a useful commodity of some sort or other? A period of a few months during 1873, as well as later, brought a number of recipes for squirrel fricassee. Surely the San Francisco market could furnish them to boarding and eating houses at a more reasonable rate than rabbits could be supplied for. The squirrels were vegetarians, ate seeds of the best type, namely, wheat, barley, oats, the forage plant and weed seeds, and from all outward appearances led a cleanly existence. One farmer had employed Chinamen among whose duties during part of the season was trapping ground squirrels, or drowning them, with the assistance of a dog. The Chinaman tried the squirrel as a "piece de resistance" with the astounding yet gratifying result, as far as the rancher was concerned, that the spare hours of the Chinese boys were spent in digging or trapping squirrels to appease the newly-created appetite. They did not skin the beasts, but scalded them rather after the fashion of a hog, ending the operating by scraping the hair off. An idea, a grain-fed hog was palatable, why not a grain-fed squirrel? Roasted young squirrel came to be quite a delicacy among the Chinese of San

Francisco. This was also true for peoples of foreign birth to a large degree, and it was not uncommon to see parties from the city out gunning for squirrels of a Sunday afternoon. It was generally conceded by the chefs, housewives and bachelors of the day that for fricassee, old squirrels should be boiled at least three hours to make them tender, the seasoning operation being left until this condition had been reached. Young squirrels became very tender in two hours, evidently due to the fact that the vicissitudes and trials of their terrestrial existence in searching for food as well as evading hawks had not been extensive enough so that excessive activity had induced toughness. A precaution to be observed immediately after killing was to draw the specimen and scrape off some of the excess fat. The idea prevalent at the time held fat to be productive of a strong flavor.

How many tons of squirrels were shipped into San Francisco and Oakland markets can not be estimated, but in the course of years, until bubonic plague infection among these rodents was conclusively proven in 1908, they would total a staggering sum. Squirrels brought

FIG. 49. Squirrel poisoning crew operating on area of state land. Poisoned grain is carried in bags suspended from saddle horn. A definite distance is maintained between each man. Every burrow is treated.

from 75 cents to $1.25 per dozen for many years, and when San Francisco became famous for fine places to satisfy the discriminating palate of the connoisseur, young squirrels brought an even higher price, inasmuch as four "frog legs" could be produced from one specimen without any serious stretch of the imagination. After all is said, the squirrel still remains a delicate morsel of food, but in view of the fact that he may be a spreader of contagious and infectious diseases, to handle him is dangerous, especially in regions where the possibility of such disease exists. This is applicable without question or reason for doubt in the counties about San Francisco Bay to the present time.

Considerable thought has been given to the advisability of finding a suitable service for the hides and furs. Could they be given the market value of hides of European squirrels, which were in such demand for making gloves? In 1877 a thrifty person had fifty squirrel skins tanned, made into gloves, and pressed into service. He took the new gloves to several manufacturers of this fastidious apparel for inspection and criticisms. The criticisms were forthcoming without a great deal of hesitancy and evidently not altogether the most favorable. Although labor was comparatively cheap at that time, the smallness of the skins called for a duplication of operations in tanning that was not compensated by the low rate at which ground squirrel hides were obtainable. This would be true too in constructing each individual glove, for an unnecessary amount of piecing would be called for when such small skins were used. The gloves that had been manufactured gave exceptional satisfaction and good service to the wearer. From time to time suggestions for using the hides or furs have been published in various journals, but results that would point toward a profitable enterprise do not seem to have matured. Great care would be necessary in looking after the carcasses if trapped or poisoned, to prevent slipping of hair by exposure to sun, also when shooting to pierce the body in such a place that the value of the hide would not be impaired. The suggestion has even been made that perhaps the tail hairs might serve as a substitute for camel's-hair or badger-bristle brushes. In view of experience with jackrabbit furs, which resulted in a hundred or more thousand being received when an order of forty or fifty thousand was placed, it was feared that the same situation might occur and swamp the market, thus causing a loss to many who were engaged in procuring hides. So far as can be deduced at present, the value as food alone stands in the ground squirrel's favor. It is known that they served as an important part of the Indian's diet from reports in early California history. Personal contact with Pit River Indians in Modoc County as recently as 1915 disclosed their love for the fat Oregon ground squirrel. One middle-aged buck volunteered the information that Oregon ground squirrel was in substance "Indian pork," consequently he resented the killing of these pests upon his land, which was serving as surprisingly good reinfesting area for the adjacent cultivated fields. Along with jackrabbit, or "Indian beef" as he termed it, and sagehen, or "Indian chicken," he saw in the destruction of the squirrel a possible meat famine for the Indians of the north. His fears were truly well founded, for many thousands of squirrels have been destroyed in a short time, and still a goodly supply remains to reseed the whole country unless followed by concerted action for their eradication.

### DEVELOPMENT OF CONTROL METHODS.

Again we take up control methods and find that as a poison strychnine was a favorite from the start. It had been used with startling success upon rodents elsewhere; was generally known to be potent and to act with extreme rapidity. The chief source of difficulty in its use seemed to lie in the practice of preparing the grain with twenty to fifty times the strength of strychnine necessary for satisfactory results.

An early formula (1873) called for 24 ounces of strychnine to two quarts of wheat. The strychnine was first dissolved and the grain boiled for a time in the solution. Brown sugar was used to sweeten.

Another control method was suggested, due to the fact that ground squirrels lived in burrows, which could have only a limited cubic capacity. Why not force in something that would stifle or suffocate them? Certain enough it was tried, and about this time one of the earliest fumigators for controlling squirrels was invented which used sulphur fumes as basis for its action. Hot coals were kept glowing by means of a draft supplied by an attached bellows while a stream of powdered sulphur was dropped upon the coals. A multitude of similar devices have been evolved, but at no time have found the favor which followed the use of later perfected fumigants.

The first commercial poison which rapidly gained a reputation was "Wakelee's squirrel poison." It was well advertised and extensively used throughout a greater portion of the state. Even in 1917 numerous localities were encountered where the virtues of "Wakelee's squirrel poison" were still being extolled. Other druggists and poison manufacturers began to place proprietary products on the market to exterminate squirrels, each with a positively sure and certain result, namely, dead squirrel. Some were secret formulas, others were patented processes, but whenever the layman saw fit to make up a batch of grain himself following a good formula his efforts were generally greeted with successful returns. The idea was widespread that crystals of strychnine and cyanide had to be used, and that the grain must be soaked in a solution of these crystals. Under practically all circumstances a sweetening substance was added, usually sugar or honey, but it evidently was not considered that the amounts prescribed had little or no effect upon the bitterness of strychnine. It was argued that if a good result was desired one must use the type of grain upon which the animal had been feeding, inasmuch as he was accustomed to it, while on the other hand it was concluded by some that squirrels desired an occasional change, hence in order to be certain of the effectiveness of the poisoned grain a different bait should be substituted.

Before 1880 contractors to do squirrel eradication were heard of in various parts of the state. One partnership, Gerow Bros., earned for itself a good reputation by doing a thorough job before asking for the payment of 5 cents per acre, which was their charge. We hear of them first in Solano County, later in the squirrel-ridden Contra Costa. Strychnine to the amount of one ounce on eight quarts of wheat was their formula, using sugar to sweeten and some sort of scent to attract the squirrel. They worked early in the day and used the most satisfactory means known to properly scatter grain, namely, from horseback. Not only could the burrows be seen more readily, but the likelihood of grain falling in piles was more remote.

The formulas for poisoned grain appearing from 1870 until the time of extensive experimentation to perfect the old formulas can be grouped into the following classes: (1) strychnine-cyanide, and (2) phosphorus. There were a few aberrant recipes using as a basis for the death-dealing qualities of the bait, arsenic and other poisons commonly used for rats.

The only evident reason for using these weaker and slower poisons seems to be the lack of bitter taste. Phosphorus may well be dispensed with early in the tale, for the great danger of fire from its use renders it unfit for general recommendation. The efficacy of a good phosphorus poison can not be denied, nor can it be said that with careful, judicious preparation and proper exposure about or in squirrel burrows that a positive ban should be placed upon it. However, formulas considered to contain very low percentages of phosphorus have been known to cause disastrous grain fires in California, and to prevent recurrence of anything of the sort everyone should be cautioned against its use. Even though used in the height of the rainy season, kernels of grain which may have escaped a thorough drenching when dried can bring about a startling reaction. Furthermore, a point generally overlooked is that it is an extremely slow poison, entailing a great deal of suffering for the rodent, and is positively fatal to swine even in small quantities. Sticks of yellow phosphorus were used, dissolved in hot water to divide into fine particles, with corn, wheat or barley boiled in the solution, to which sugar was added and later oil of rhodium. This truly is a rough method of handling, but even to date the formula has not been smoothed out to any marked degree. When carbon-disulphid became common on the Pacific coast it was used to dissolve phosphorus to some extent; still this information did not seem to receive general recognition. In practically all cases heavy syrups were made, in which the grain was soaked or even boiled. After this process flour, middlings or cornmeal was used to dry the bait. One pound of phosphorus to a half sack of wheat or about a stick to the gallon of wheat in smaller lots seem to have been the generally accepted amounts. An unfortunate practice used in connection with poisoned grain was partly to blame for fires with phosphorus, namely, the stopping of burrows with newspapers after having thrust the grain down below the opening. Knowing ranchers were careful in this regard and considered it a useless procedure; still many were confirmed in their supposition that the rattle of the paper frightened the squirrel into remaining underground, consequently in order to feed he must eat the poisoned grain. Many held that paper alone would confine the squirrel to his home and result in final starvation, evidently forgetting this rodent's mining proclivities, which would lead to the construction of new openings.

In the case of strychnine-cyanide preparations the general opinion regarding the violent poisons was that if some is good, more is better, hence we generally find the two going together in one mixture to make a "dead-shot" squirrel poison. If the poison was doubly strong only half as much grain need be used, consequently only half as much need be exposed at the ground squirrel burrow, and, as usual, when one squirrel posing as the early bird would appear, for his morning repast, he would devour post-haste the entire amount. For exhibiting this greed he suffered just deserts, but widow and offspring went unscathed, much to the dismay of the farmer. The logical conclusion to be arrived at: the strychnine was adulterated—it must have been half-quinine or perhaps contained cornstarch or flour. Many did not consider the appetite possessed by birds and other small rodents for

grains. In mentioning the morning feeding of ground squirrels this point is brought to mind, that from the use of cyanide it came to be habitual among many ranchers to expose poisoned grain either late in the evening or early in the morning, for it evidently had been learned from experience that cyanid was volatile in the atmosphere, rapidly decomposing and leaving the grain. Unless exposed with the view to having it consumed within twenty-four hours grain should not be used unless with strychnine, which will remain to render the poison effective for a long period, provided it is not washed away by heavy fogs or rains. The use of gum arabic to form a moisture-resisting coating substance in which strychnine had been dissolved was used as early as 1877, but did not come into general use. In later experiments upon poisoned grain this gum was used to learn if it would make possible the use of a coated grain bait throughout the rainy season.

Of all formulas in use prior to the advent of our present perfected one[1], the exterminator termed "dead-shot" seems to have had general approval. When the Board of Supervisors of Tulare County appropriated $500 for each supervisorial district, it was this formula that was to be followed to the letter inasmuch as the satisfaction it had given proved it to be a worthy article. Essentially the ingredients were wheat, 25 pounds; or barley, 30 pounds; strychnine crystals (sulphate) 1 ounce; cyanid of potassium, 1 ounce; strained honey or syrup, 1 quart; water, 1 gill; peppermint, 5 drops; anise oil, 7 drops, with a little oil of rhodium or cummin thrown in. Interesting deviations from this were noted, still all ingredients used differing in kind or quantity gave essentially the same result in the end.

In general for all formulas pennyroyal, anise, rhodium, peppermint and cummin were used for scent. A suggestion found in one article leads to the belief that pyroligneous acid might have been used in this connection inasmuch as it would give the flavor or scent of smoke.

For sweetening almost anything or everything producing a sweet taste was used—black molasses, sorghum, maple, corn or sugar syrup, strained or comb honey, brown sugar, white sugar and powdered sugar. The use of saccharin did not come into vogue until a considerably later date. It was noted that it was not necessary to soak the grain in strychnine, but that any coating which would hold the strychnine served the purpose admirably. The media for this were mostly flour pastes and syrups, white of egg, starch paste, gum arabic and rice paste. The perfecting of these various ingredients as to quantity and kinds was later done by Mr. S. E. Piper of the U. S. Department of Agriculture, as related in a following article which brings out the details in very good style, stressing reasons for the ingredients being in the formula and why a coated grain is most acceptable.

This perfected formula came to be known as the Biological Survey formula, and its use over a number of years has proved an efficiency yet to be attained by any formula developed.

The mention of coated grain calls to mind the carrying of grain in the cheek pouches, the capacity of which has been exaggerated in a great many instances. In this regard we have records taken from the *Pacific Rural Press* of actual counts, some of which are submitted for

[1]Appendix, p. 790.

the benefit of those interested. From the Capay Valley of Yolo County in 1877 comes word of 1,520 kernels of wheat, while a citation of the Watsonville *Pajaronian* gives one ground squirrel credit for lugging 1,270 kernels of plump wheat at least one-half mile from a grain field. These are bolstered by two more records, one from the San Mateo *Journal* in July, 1881, wherein 1,078 kernels of chevalier barley formed the load; the other from the Contra Costa *Gazette,* mentioning 1,834 kernels from the pouches of a single squirrel. We truly feel that these are positively outstanding instances, for personal observations have disclosed an average of from 350 to 500 kernels of grain during the storing period.

FIG. 50. Pack train supplying crews at work destroying squirrels in the more mountainous districts.

Utilization has been made by a number of field men of thick syrup as a medium to hold strychnine and other poisons, which when trod upon by rodents would adhere to the foot-pads. The sticky substance would naturally cause the squirrel some discomfiture, which might be allayed by licking the bothersome stuff from the feet. Strychnine would thus be ingested in the process of removing the syrup. This truly is not a common means of controlling squirrels, but like the use of various kinds of bait, such as melons, dried fruits, grain heads, cull deciduous and citrus fruits, bits of bacon, dandelion root, acorns, buckeye nuts, etc., with strychnine has served where the more common expedients seem to have failed in the control of the few wise and sophisticated ground squirrels.

Likewise concentrated lye, which has been used with success, much as the syrup, for moles and gophers, might perhaps be of some avail against squirrels. Licking the substance from the toes allows it to get into the mouth with disastrous results for the squirrel.

On one occasion the use of sulphur fumes to suffocate squirrels has been referred to as common during the early '70s, which method was a final resort for action during the rainy season when poisoned grain did not seem effective. But there have been very few new ideas along squirrel control lines that have put so much impetus behind squirrel

eradication nor have caused greater interest in control methods than the announcement by Professor E. W. Hilgard of the University of California Agricultural College in 1878 that carbon disulphid absolutely would rid an area of ground squirrels exactly as he had demonstrated on the University of California campus at Berkeley. He argued that of the poisons in the shape of scattered or exposed baits there was grave danger to stock, and further that a good sheep dog might be killed by eating poisoned squirrels. Even danger attended the mixing of such poisons before the person intending to use same should leave the house, where children or poultry could gain access to the mixing utensils.

Hitherto viticulturists had used carbon disulphid in attempting to control phylloxera on grapevines, and while attending a grape-growers' session in Paris Professor Hilgard learned of its use as an expedient to get rid of rats in sewers of that city. The method of application suggested at first was rather expensive, as it called for pouring a measured amount into the burrow from some sort of a vial. Professor Hilgard explained the properties of the substance in detail[1], noting its mode of preparation, that it was heavier than air, and its effectiveness as a fumigant for squirrels. He used about one pound to the acre on an average infestation, which at that time would cost about 45 cents. This meant $4.50 per gallon, a price conceded to be too high for general use. All of the carbon disulphid coming to the Pacific Coast was put up in pound containers, had been refined for chemists' use, and although it cost but 12 cents per pound in St. Louis, by the time the express was added the cost was close to 50 cents per pound. The high charge was partly due to the increased rate assessed on account of the danger attending the handling of an explosive substance. In 1879 we get the first suggestion for using wasteballs from Australia, for in that country the method was being tried on rabbits. Wads of cloth were used, over which the carbon disulphid was poured. Uniformly good results were reported from use in rabbit burrows. To get a manufacturer to undertake the production of carbon disulphid in California was another question, and it was about ten years (1888) before we learn of Wheeler's carbon disulphid appearing on the market.

Thus carbon disulphid filled a decided need for a substance which would permit continuous ground squirrel control work throughout the full year. Up to this time poisoned grains were considered the best for all-around work. Professor Hilgard had called to the attention of all interested the fact that this gas was most practical for use in wet ground and that rather a large amount of waste would be entailed when the soil was dry and cracked. The early manufacturer of carbon disulphid recommended the use of a bottle or bucket for carrying the carbon disulphid; application to be made with a funnel to which a long hose was attached (Fig. 45). We know this to be a very wasteful method, still the success with which the landowners met in using the stuff made them so enthusiastic that cost was in a measure forgotten. The waste-ball plan of using carbon disulphid soon came to be looked upon as a conserver of the liquid, and still later by the invention of the

[1]University of California Bulletin No. 23, 1878.

various pumps, blowers or vaporizers a very great saving of material was occasioned. The last mentioned contrivances found their perfection in the U. S. Destructor, invented by Dr. J. D. Long of the U. S. Public Health Service in 1912[1]. Each of the methods of use was accompanied by disadvantages. By the funnel method a great many burrows could be treated in a single day, but with great loss of material, and while the waste-ball plan found a saving in carbon disulphid, it also resulted in slower work; and in the case of the destructor practically no wastage of material was evident, but the length of the time consumed and the number of men required in operating the contrivance nearly made up the difference in added cost for labor.

It seemed to be a difficult matter to get away from the sulphur fume idea and throughout the years when methods were eagerly sought we note that someone is constantly reverting to the old idea. In 1883 a farmer rigged up an apparatus, the equipment for which, if bought at present war-time prices, would practically bankrupt an average rancher. A large sheet-iron cylinder six feet long and a foot in diameter was rigged up with a flexible hose 12 feet in length at one end and a blacksmith's bellows at the other. In the cylinder barnyard litter and straw into which charges of sulphur were introduced was burned. Fumes were created which could be seen issuing from open burrows at a considerable distance. When the operator of the bellows believed all holes were fuming sufficiently to insure spread of the gases throughout the underground runways the holes were stopped up and the next colony treated. Repetitions of this type of fumigator are often mentioned in periodicals of the day. Short lengths of rope were cut up, loosened, soaked in melted sulphur, allowed to dry and then lighted in the burrow. The rope burned slowly and produced dead squirrels—which was the result desired. On par with this creation were swabs of old cloth or rags on the end of a stick dipped first in melted sulphur, then coal oil, the latter insuring proper combustion. It was recommended that the hole be left open for some time in order that sufficient draft be furnished for a lengthy period of burning.

The present day forms of sulphur fume producers are sold as "gopher or squirrel balls," or exterminators of different names, usually consisting of a slow-burning base such as sawdust or charcoal mixed with sulphur and gunpowder, the latter to promote combustion. Other chemicals are sometimes introduced to make the fumes more irritating. Another form, a cartridge, has gunpowder in slightly larger quantity to make burning more rapid, and generally contains a heavy charge at the base of the cartridge to produce an explosion, forcing the fumes or vapor produced to all ends of the squirrel burrow. The effectiveness of these various products can not be said to be wholly uniform, for in many cases reports are received of their unqualified success as rodent eradicators against reports of failure. It is, of course, a mistake to think of using them with maximum efficiency at any time other than when much moisture is present in the soil; in other words, the rainy season. Blowers for dry sulphur are now being equipped with a little extension having a burning pan or nozzle for igniting the finely divided particles of sulphur as the sulphur is blown out through the nozzle tube,

[1]For details see Circ. 181, Univ. of Calif. Ag. Exp. Sta.

and the effectiveness compares favorably with that of the sulphur fume methods.

It was some time before the practice of exploding carbon disulphid became general; as a matter of fact, even at the present time individuals are encountered who are unfamiliar with the method. The advantages and possible disadvantages have been treated by Professor Burd in this issue, consequently reference is made to his contribution. In leaving carbon disulphid this much should be said: That in our experience this substance, together with the chemical combinations of it sold under different trade names, are by far the best we know at the present time, taking into consideration the economy in labor, time, and materials, and in view of results obtained.

Before laying aside vapor methods, it may be advisable to mention distillate, gasoline and kerosene. When these explosive liquids are ignited in a burrow they produce fumes which are known to be deadly, just as are those exhausted from a gasoline motor. A possible advantage is the cheapness of these products in comparison with carbon disulphid by allowing a greater quantity for each dose, but use of them has yet to prove a percentage of efficiency high enough to warrant their general adoption. A patent vaporizer for distillate has been on the market for a number of years, which has been approved by many. In a few regions where peculiar soil types exist even the demonstrators have admitted little success. During warm weather, when a cold ground does not condense the vapor on the burrow walls, excellent results have been observed, but unfortunately this is a time of year when the less expensive poisoned grain does good work. During the winter it is necessary to force a far greater volume of distillate vapor into each burrow, and even then we are not assured that a vapor state of sufficient duration will be maintained to keep the ground squirrel from reviving. If it is necessary to repeat the operation too often labor charges will eat into the low cost of operation which appears as an advantage in the summer. Attendant danger of explosion is not serious in handling the apparatus if necessary precautions are observed.

There still remain numerous vapor and gas methods to be tested. Perhaps the foremost of the remaining are hydrocyanic acid gas and chlorine. Where fumigators of citrus groves have been at work using either the cyanofumer or liquid cyanid process, dosages have been tried out on squirrel burrows with satisfactory results. The cyanid gas, being lighter than air, could not be considered in this connection to affect a 100 per cent cleanup unless considerable force can be placed behind the charge. Rapid expansion of the gas upon release from the liquid state might supply some pressure, whether sufficient is doubted. Being lighter than air, cyanid gas might fulfill a requirement lacking in carbon disulphid, namely, that of rising over some of the higher spots in a burrow; but would collect in these higher places unless forced on. We know that killing by this gas is better in the tops of trees, giving good evidence of the rapid rise of the vapor. Death would be practically instantaneous, an advantage to be considered; still the combination of the gas with moisture in the burrow and the high cost of operation would detract to some degree from the possible use. Unless one lived in a citrus district where materials were to be had on short notice or in quantity it would not be advisable to try.

Chlorine has been tried out by Horticultural Commissioner A. A. Brock with favorable results, and with gas impounded under pressure in cylinders with a calibrated apparatus of some sort for measuring quantity, a future for this method seems promising. The cost will be very low, perhaps only a fraction of a cent.

Attention has been called to a means of combating meadow mice with calcium carbide and water to form acetylene gas, with good results.

It has been the policy of the Rodent Control Division of the State Commission of Horticulture to "try out" various commercial and proprietary products and compounds exploited as being the most effective on the market for controlling noxious rodent pests. This is done merely to satisfy the personnel of the division that the product has some grounds for being on the market, but at no time have written statements been given out vouching for the superiority of one preparation over another, unless it was felt that by so doing the standard of all offered for sale could be bettered; this then affected not one but all. If there are not available enough elemental or original ingredients for a landowner to prepare a suitable rodent exterminator himself that is a different matter, but in these days this does not chance to be the case. If a manufactured article must have the endorsement of public officials to further its sales, the inference generally drawn is that it can not stand on its own merits. If demonstrations are in order, they should be made to the people for whose benefit they have been prepared and to whom they are offered for sale. It is believed that strict adherence to such a policy will obviate any criticism involving discrimination against any particular product.

Questions have been asked of all field men combating squirrels if some disease could not be isolated which when inoculated into ground squirrels would spread rapidly enough to insure a final epidemic. It must be admitted that nothing is known which will bring about such results. However, at one time such a disease was supposed to have been produced by the so-called Pasteur Rodent Virus. This preparation was a culture of a disease germ reputed to have been isolated at the Pasteur Institute at Paris. It had been exploited in Europe, whence it came with recommendations, and in the eastern United States, before being brought to the Pacific coast in 1896. It seems, however, that rather too extravagant claims were made for this particular virus before it was given a test on the California ground squirrel. The method of application called for equivalent amounts of the liquid virus and boiled water to which a little salt had been added; two or three small pieces of bread, which had been dipped into this combination were "set" at each burrow. The contagion was intended to spread, with fatalities among ground squirrels for miles throughout the locality. Reports of success came from here and there, but the results of the use of this product were at no time such as to cause a heavy demand from dealers. It was harmless to all domestic stock, excepting some effect on poultry, and this called for caution when used about yards and barns. A veterinary in Fresno County did some good work and one report from Santa Barbara gave a boost. It was tried on rabbits, using raisins and corn for bait. No report of any particular moment ever came of this. As with all such preparations, the dependence upon the possibility of close contact of individuals of the species proved to be a useless one.

In the open the contagion was transmitted with difficulty and this evidently explains the failure of the virus or at least the lack of good reports. The mention of control methods in this article is made merely to bring out what has been done, giving an idea of what there may be yet to do. Details have been necessarily avoided, for each phase of the control measures involves in itself a lengthy discussion.

FIG. 51. A community poison mix to which grain and other ingredients were brought for preparing poisoned grain. Everyone helped, the job was finished quickly, followed by a barbecue.

## EARLY ORGANIZATIONS.

Progress in agriculture and horticulture was marked during the '80's and '90's by increasing numbers of land settlement colonies springing up here and there about the state. The position California was to occupy as a food base for the nation was already well indicated, for the possibilities were yearly becoming more evident as application of scientific information was practiced. Irrigation schemes and projects were under way, men with experience along agricultural lines were being attracted by the successes of those already in the state, and although the farmer continued to be the victim of low prices better times were assured, in view of the class of farmers taking hold of crop production.

Getting back to ground squirrels, we find that nothing startling occurred along control lines, for whenever depredations became noticeably severe, the county board of supervisors of each county was looked to to relieve the situation, which generally came about in the form of an ordinance establishing a force of district inspectors or an enactment providing for a bounty. New ranchers continued to raise crops and fight squirrels as had those preceding them or those on the land adjoining, instead of destroying the squirrels and raising crops. Reports of destruction of trees and plants came in to those interested in such information, from time to time. In 1902 grave fear was expressed for the safety of the orange groves, for the squirrel had developed a taste

for orange bark as well as the fruit, either green or ripe, and in 1904 we received the news that the Oregon ground squirrel was rapidly getting to be a source of worry for growers in northeastern California. These little marauders provoked protests from residents of the Pit River drainage system as a whole as far as eastern Shasta County. Ranchers spoke of the pest as a "prairie dog" just moving in on the crop, for in many instances the "old-timers" tell of the presence of this squirrel being unknown until recent years. Even now we hear of slow spreading to localities where a few years ago they were unknown.

It must be granted that co-operative effort against rodent pests was recognized very early, but was not practiced to an extent which might warrant the ridding of a considerable area of ground squirrels. The field for such departures was enormous, and some farmers' clubs took the matter in hand with a will. Dreams of a statewide campaign against rabbits as well as squirrels are mentioned in papers and periodicals of the day but no organization was perfected to handle such a deal.

In Los Angeles County residents of the Cahuenga District organized a squirrel club as early as 1877, for the purpose of conducting a squirrel "killing bee." This was a very dry season in southern California, the squirrels taking poisoned grain with great avidity, and they could be attacked easily because of their habit of migrating to places where vegetation abounded. This same year at Guadaloupe in Santa Barbara County, funds were subscribed by landowners, who had banded together to form a squirrel club, to purchase poison supplies in large lots to mix up dope according to one of the prevailing formulas. A good start, with good results, followed. Years of exceptional ground squirrel increase were replete with expressions of effective work in districts. In 1889 Contra Costa County had a number of meetings, the most important of which was held at Walnut Creek in January. At this meeting plans for a concerted drive were discussed, as well as methods of control then in vogue. A signed statement was made by all present pledging their desire to do everything in their power to work concertedly. Certain times for work were set and these were to be followed religiously. One selfish individual present had a poisoned wheat preparation for which extravagant claims were made and the formula for which would be parted with only for the sum of $50.00. A committee was to try the product out and report on its worth, then to decide whether the price should be paid or not.

Among other clubs organized was one at Manteca known as a "Squirrel Association," which had been given start by a woman and virtually was a women's club. Socials, plays and dances were given to raise funds wherewith to support the order and to supply prizes to the boy or girl turning in the greatest number of tails from dead squirrels. A bounty of 1½ cents per squirrel was paid to those not capturing prizes. The prizes were all of a practical sort, useful articles of apparel or something of educational value. The action continued throughout the season 1903 with plans for a continuation for the following year, but evidently because the leader of the movement left the district, these were not carried out. As it was aptly put, "the men continued to attack the squirrels with profanity," and did not use anything of a particularly death-dealing nature.

From this type of organization we advance to that where a man especially trained in all phases of rodent habits, life history and methods of control takes an active part. During the years when the United States Department of Agriculture had men in the field conducting special investigational work in exterminating rodent pests, very often an opportunity was offered to help out a community sorely in need of the proficient services of such field men. Mr. S. E. Piper of the Biological Survey did this work in a number of counties, depending upon those active in the welfare of the community to follow the work up, for his schedule could be in no wise anticipated from year to year. Lack of proper legal procedure at any one time gave a most acceptable excuse for anyone not inclined to rid his fields of squirrels. This fact alone discouraged many from continuing the work they themselves had started. The next move which foreboded considerable success was the taking up of county-wide campaigns by the farm bureau organizations under the leadership of farm advisers. In 1915 Ventura County went through such a campaign under the guidance of Farm Adviser Wm. B. Parker, backed by an ordinance which gave fairly broad powers. Other farm bureaus undertook the handling of poisoned grain at wholesale cost which entailed a great saving for those taking advantage of low prices.

We have in a measure neglected the legal phase of rodent control, although referring from time to time to laws and ordinances.

### LEGAL AID IN CONTROL WORK.

Farmers' clubs, with other organizations having agricultural and horticultural interests as a basis for their existence, began very early to appeal to legislators for laws more adequate than those extant or those that had been rescinded. One legislator of Alameda County suggested a joint conference of Alameda and Contra Costa County people at which a law could be drafted for submission to the legislature, after having been passed upon by good legal advisers. Another legislator admitted that the law at hand was inoperative and strongly urged the preparation of a good compulsory law to follow the rescission of the bounty acts. The increasing damage to crops continued to elicit information bearing upon the best procedures to follow. One conception of proper means is illustrated by a statement that the board of supervisors of each county should appoint for each township an inspector, whose duty it would be to make note of every open squirrel burrow, for each of which the county auditor was to levy a charge of 50 cents. The moneys so collected would be divided equally between the school fund and the salary of the inspector. One regrettable feature, of course, would be to control pests on the government lands, but this would be compensated for by compelling many holders of big tracts to get rid of lands being held for speculation, for eradication costs would be greater than the values set thereon. In the end a convention was called for October, 1873, which meeting all interested were urged to attend, especially members of the legislature, farmers' clubs and granges, who should bring with them some sort of a drafted law or at least good ideas as to what was needed in a legislative way. The bay counties were well represented, and even San Joaquin County had sent envoys.

The benefits and inadequacies of the bounty plan were thoroughly aired and finally it was agreed by all that nothing short of a compulsory law would serve. It was brought out at this meeting that only one head of stock could be supported where formerly two could subsist on the wild oats of the range, that in sections range lands were worth only a fourth of their former value, and in Contra Costa County alone the damage was no less than a quarter million dollars. As at most conventions of this nature, lengthy discussions over minor details arose, especially when it came to levying a tax to pay inspectors, or to amounts and methods of collection of bills against the landholder. Would it be just to allow the landowner to go on the land to eradicate squirrels if same was leased? Should a tax be levied on the basis of the number of acres or upon the value of the land, and would there not be more or less hardship thrust upon the nonresident, were points bringing up ridiculous discussion to such an extent that finally a committee was appointed to draft a suitable legal document to cover all phases. Those assembled had many interesting methods of control to present, some of which showed indication of considerable value. In the course of a few months the newly drafted law was forthcoming and it was essentially this particular one which was adopted almost to the word by the legislature of 1875–76.[1] The amount to be levied in order to meet the expenses liable to be entailed by the act, was to be a tax of not less than 20 cents per hundred dollars taxable property within the county.

Some comment of this law was published, finding fault with it chiefly from the angle that the wages allowed the inspectors were but half enough. While men could be hired at $2.00 per day, still it was quite certain that the type of men entrusted with the proper enforcement of the law should be paid at least $4.00 in order that efficient service might be commanded. He should have qualifications that would make him unafraid of any landowner, and should command the respect of all. Low wages might often lead to dishonesty among inspectors in whom absolute confidence should be placed.

In July, 1875, a rather interesting copy of a possible law appeared in the *Pacific Rural Press*. A rancher from southern California is responsible for some of the rather extravagant ideas expressed. In summary the following points are embodied: (1) Every school district a squirrel district with (2) a squirrel master in charge, who shall be appointed by the board of supervisors upon request of one-fourth of the voters; (3) The squirrel master must file a bond and (4) can appoint all necessary inspectors; (5) The school trustees were to look after the levying of taxes; (6) The time of year was stated, together with (7) arrangement for meeting at certain place at 7 a.m.; (8) The Board of Supervisors was empowered to prescribe certain regulations to be applied by the squirrel master; (9) A rancher's liability to appear could be commuted for $5.00 and (10) anyone not so doing, or who did not appear in person or by proxy, was guilty of a misdemeanor; (11) Likewise to violate a prescribed regulation or a rule of the squirrel master was a misdemeanor; (12) The squirrel master alone could draw warrants on the tax and commutation moneys paid into the treasury; (13) Purchase supplies and hire men for special duty in this in con-

[1]Statutes of California 1875–76, Chap. CXLIV, p. 143.

trolling squirrels on vacant land; (14) The squirrel master had all the books of his business to keep and (15) served at the discretion of and compensation set by the Board of Supervisors.

We are gradually coming to the place where this work must be entrusted to competent men who are or should become specialists in squirrel control. The impelling idea behind such a movement was, of course, the vesting of power in a competent man who should be an officer of the law much as a sheriff, and in whom a community could have absolute faith. The final recognition of such a need was given by the legislature of 1875–76 when, under an act passed March 7, 1876, boards of supervisors were empowered to create squirrel inspection districts over which districts a district inspector should be appointed at $3.00 per day. Recommendations of landowners or occupants of land in a squirrel inspection district were to be considered in the appointment of the inspector. The law gives the first Monday in October as the time when all should start work on their lands, and this work should be diligently prosecuted until all squirrels were destroyed. If active warfare was not instituted against the squirrel within three weeks the inspector could serve notice of his intention to proceed with the eradication in office of County Recorder. The occupant of the land would receive word that such notice of intention had been filed and could pay all bills accrued directly to the inspector to save the 10 per cent which would be added, if the expenses were filed with the Recorder. If the bills should be filed with the aforementioned county officer and no payment made within 90 days, said bills were turned over to the District Attorney for foreclosing lien proceedings.

The district inspector could hire men at the rate of $2.00 per day to clean up the areas where negligent owners refused to do the job. This hiring of men was evidently confined to the months covering the period from October to April, during the rainy season, so to speak.

The law provided for the levying of a tax to create a squirrel nuisance abatement fund from which all expenditures were to be paid and which fund was reimbursed by the collection of the liens. Owners were privileged to clean up their lands if the occupant refused, but he must be responsible for any unnecessary damage to premises or crops. One advantage was that all acts in conflict with this one were summarily repealed.

The moral effect of laws was without question of exceptional benefit to the counties wherein they were applicable, but we hear of no particular successes resulting from their having been enacted. Inefficient and undependable inspectors soon caused more or less diffidence and distrust on the part of the ranchers.

Land colonies had been promoted and exploited for some little time with the natural consequence that many new and inexperienced people were becoming ranchers. The breaking of soil for the first time disturbed squirrels to a limited extent, but it was not long before their inclinations in favor of a new diet brought them to the fore as highly destructive invaders. As the colony idea spread local need became greater for suitable authority to deal with the squirrel nuisance, and when the twenty-fifth session of the legislature prepared and passed

"an act to establish a uniform system of county and township governments," the general permanent powers of a county board of supervisors included the authority "to provide for the destruction of gophers, squirrels, other wild animals, noxious weeds and insects injurious to fruit or fruit trees, or vines, or vegetable or plant life."[1]

From this time on we have the regnum of county ordinances and bounty acts. All bounty acts that were passed by the legislature to affect certain counties had been repealed by the legislature by this

FIG. 52. Central mixing depot of county horticultural commissioner preparing poisoned grain on a large scale. Numerous large mixing boxes are provided, each serving as its own drying tray. Large batches are mixed in this type of box.

time, hence there were no conflicting regulations in force. Some counties never adopted the ordinance scheme to create inspection districts, usually allowing bounties to prevail or passing and repealing bounty acts from time to time. Evidently it was deemed better by the supervisors to spread their patronage more widely and evenly over the county by paying a bounty than to tie it all up in a few inspectors as it actually resolved itself in a very short time.

The duties of squirrel inspectors became rather honorary in nature, with as little actual work or activity as possible. The old saying that "the inspector did most of the field work at the county seat or about the country store," held good in many instances, and not very long ago an authentic report was received to the effect that the inspector hired by the county to look after the squirrel menace was haying for the chairman of the board of supervisors, although paid from county funds. An unfortunate circumstance arose in many counties wherever funds were running short, for just as with bounties, the squirrel inspector expense was among the foremost, if not the first, to be clipped off. When the position of inspector became a pension its value to the community was

[1]See footnote, p. 729.

lost. Furthermore, the excuse that the ordinance would not be upheld in the courts, for experience had proven that such was the case in many instances, was a talking point for the negligent landowner and a loophole for an inefficient inspector. There were, however, a great many ranchers who always abided by the ruling that it was better to pay for the killing than for lawsuits or lying to the inspector.

In 1889 damage from ground squirrels was very severe, complaints coming from all over California. Alameda and Contra Costa County residents were up in arms, which resulted in a joint meeting of the boards of supervisors in April, 1889, as a consequence of which it was agreed that a new ordinance be tried out, which when presented to the District Attorney in August, was commented upon by his office as conceding too strongly that the squirrel was a nuisance. He suggested that this matter be allowed to go before the courts, in which case a final decision could be obtained. The ordinance adopted by the Contra Costa board to take effect on November 30, 1889, came before the Supreme Court in 1890, with the result that it was declared unconstitutional. From the decision we take the following comment:

> "It (the ordinance) is certainly a most effective means of abating a nuisance, viz, the squirrels, and bringing about a very desirable end. We regret exceedingly that we can not see our way clear to uphold and enforce such an important and original piece of legislation. Indeed, it would give us great pleasure to see the power here assumed applied to snakes, tarantulas, ants, flies, fleas and other reptiles, insects and pests which tend to make man's life a burden, and to have it exercised and enforced in every county in the state. But we are unable to see by what right or authority of law a board of supervisors can impose upon a landowner the burden and expense of exterminating animals *terræ naturæ* on his own land or elsewhere. * * * We know of no law which can be held to authorize a board of supervisors to enact such an ordinance, and we are quite clear that it can not be enforced for the reason that it is unreasonable and burdensome in the extreme. Let the petitioner be discharged."

The ordinance was one typical of the day, declaring squirrels a nuisance, calling for extermination within 90 days and making violator guilty of misdemeanor. The violator in this case was lodged in jail in default of fine. No lien proceedings were instituted. The regrettable feature of this decision is that all ordinances were for the time disorganized, for every district attorney who looked upon such ordinance enforcement as a disagreeable job, crept behind the Supreme Court decision. Result was a period of comparative inactivity against squirrels from the legal side, and county supervisors were advised not to tie up to an unconstitutional ordinance. Fortunately, it has been proved that ground squirrels can be exterminated far more easily than weeds, which the decision admits can be controlled, consequently the excuse that man has no power to control wild beasts is without force any longer.

Evidently squirrels were making themselves noticeable in San Benito County in 1889 as well as elsewhere, for a stringent ordinance was passed, a paragraph of which is here quoted:

> "Any owner or occupant of lands, whose lands are free from squirrels or gophers, or who is endeavoring to destroy the same on his own lands, may give notice to the owners or occupants of adjoining lands whose lands are infested with squirrels or gophers, and who is not using due diligence, nor endeavoring to destroy said animals, to immediately commence the destruction thereof. And if said owner or occupant of said lands so infested does not comply with said demand within ten days thereafter, then the person giving said notice, or his

agent or employes, may enter upon the lands so infested for the purpose of destroying, and may destroy, said squirrels or gophers. And the expense thereof shall be a claim against such owner or occupant, and a lien upon said land in favor of said adjoining landowner or possessor giving said notice. And said claim may be enforced in any court of competent jurisdiction, and a judgment obtained therefor against said owner or possessor neglecting to comply with said demand. And said lands of said persons shall be sold in satisfaction of said judgment."

Allowing an outsider to proceed against the squirrels on the land of another truly was an unheard-of procedure. An appalling condition must have been prevalent. Inasmuch as we hear of little being accomplished under this ordinance, we believe the Supreme Court decision spelled its doom as well.

The next period of extensive legislation against ground squirrels follows the discovery of these animals as bubonic plague disseminators. The legal phases of rodent control were handled by the state board of health in co-operation with the United States Public Health Service. It might be well to review the work of the public health service in ground squirrel eradication.

After the exploitation of Pasteur's Rodent Virus residents of the San Francisco Bay counties were beginning to expect almost anything startling of a scientific nature for destroying ground squirrels. This new scheme was announced in 1896 and publicity was accorded it for several years. Whenever a ground squirrel was found dead, or an area appeared to be cleared of them, due to no particular artificial means, the inference drawn was that the virus had been used. There was more or less association of such scientific modes of procedure with the university at Berkeley, hence when in 1902 a type of disease was noticed to be prevalent among squirrels of Contra Costa and Alameda counties, the residents stated that a professor at the University of California had isolated a germ which was being disseminated in the Berkeley Hills by the students. Until 1905 ranchers continued to write to the university for dope to start a squirrel disease in their localities. The university men continued to deny association with any preparation or knowledge of the disease. Pasteur Rodent Virus was accorded credit for a great deal of the killing but there is not a particle of sound information upon which to base such a credit.

Ranchers wrote to the agricultural papers telling of the plague, as some began to call it, stating that already it had saved considerable work. The death of the squirrels seemed to be very local, for only occasionally were large areas noted over which squirrels had disappeared. Part of this time market hunters marked that certain of the squirrels killed had thicker, darker blood and spots in parts of the tissues; also that these squirrels would spoil very much more quickly than those appearing normal. An observation made about this time disclosed several ectoparasites, chief of which were lice and some very large fleas. Even after the use of carbon disulphid became common, those using this substance to destroy squirrels found that when applying the dose fleas jumped from the mouth of the burrow to the clothing of the person so engaged. The squirrels were grossly infested by fleas and lice, for specimens would be found with the skin scraped in many places, due to what was supposed to be excessive scratching; hence the inference that they were so weakened by the presence of the vermin

that they readily became victims of disease. Whether the disease observed among squirrels as early as 1902 can be associated with the infection actually verified in 1908 at the laboratories of the United States Public Health Service as bubonic plague, can not be determined definitely owing to lack of tests. It was suspected, however, by officers of the health service that such a condition existed as early as 1903.

Bubonic plague, as a disease, was first observed in San Francisco in 1900, and in February, 1901, six out of thirteen suspected human plague cases in Chinatown proved, upon special investigation, to have been that disease. Deaths to the number of 113 brought a cessation of human cases in about four years, but after the earthquake, in 1907, new cases began to appear. Thorough measures were inaugurated to suppress the increase of rats, which were the then known disseminators of the infection, and rigid enforcement of sanitary ordinances was followed. Bounties were even paid on rats, entailing the outlay of a considerable sum annually. Proofing against this rodent, use of poisons and trapping, was continued as before.

In the fall of 1908, cases of bubonic plague among ground squirrels were isolated from Contra Costa and one case from Los Angeles. This last-mentioned case was not followed by others, as happened with others in the state. As much information as could be obtained on the life history and habits of rodents was disseminated in the infested areas to keep residents on guard for cases of plague. During the following year plague continued to be found among squirrels, chiefly in Contra Costa County, and a state-wide hunting campaign to learn the extent of plague infection was carried on; at the same time every effort was being made to destroy squirrels locally in Contra Costa.

A law was approved in March of 1909[1] so modeled as to make the extermination of rodent pests a duty of all landowners. Unfortunately this law was thought unconstitutional, and it was judged advisable to await action of a later legislature before the legal phase should be again put in suitable shape.

### CAMPAIGN OF U. S. PUBLIC HEALTH SERVICE.

After an intensive search over a large portion of the state, many counties were found to harbor plague-infected squirrels in regions where the safety to human health was seriously jeopardized. Consequently, during the fall of 1909, a general campaign of eradication was to be conducted, especially in Contra Costa County. Free poisoned grain was distributed, as well as carbon disulphid, to the residents of the above county, with the agreement that it be judiciously and economically used. Results of a successful nature were reported, and as a safeguard against a possible influx of plague infection the idea of a "squirrel-free zone" was carried out by actual operations, which zone reached its highest point of efficient protection in 1913. Toward the end of 1911 the hunting had been extended to 45 counties of the state, but cases of plague among squirrels were discovered in only 12. Infected squirrels killed east of the San Joaquin River began to cause anxiety in that the ground squirrels were ranging to the mountain passes, the altitudes of which were lower than were the highest elevations at which the

[1]Statutes and Amendments to the Codes, California, 1909, extra sessions 1907, chap. 204, p. 311.

species were to be found, and furthermore the wood rat had been discovered to harbor the plague flea. A possibility of the transmigration of the Sierra Nevadas would thus be established by way of the low mountain passes. After bubonic plague had been discovered east of the San Joaquin River near Ripon, fears gained currency of the rapid spread of the disease up through the foothills into the mountains, across the mountains east into Nevada, where other rodents could carry the flea harboring the bacillus of bubonic plague, and possibly the prairie dog also would be instrumental in its dissemination still on to the eastward where city rats again might be the host of the flea.

On the strength of the possibility, pointed out by the United States Public Health Service, which might arise from the rapid spread of bubonic plague among ground squirrels throughout California's valley, even into the forests and mountains, allotments to prosecute the eradication of rodents upon public lands and national forests were eagerly sought, and a more plausible argument than safeguarding human health had never been advanced hitherto, for economic losses did not seem to appeal as being serious. An appropriation to eradicate noxious rodents, particularly ground squirrels upon national forests, was turned over to the Bureau of Biological Survey, United States Department of Agriculture.

In 1913 extensive operations were carried on by the Biological Survey on national forests and public domain which have been continued up to the present time. The only control methods applied upon national forests prior to this time had been instituted by interested forest supervisors or district rangers. In many localities excellent results had been obtained which, when followed up properly, demonstrated an increased value to those grazing stock on these forests.

So far as records show, the plague was never found within any of the national forests where the infestations of ground squirrels were heavy. Nevertheless, the value of the work in eliminating a source of reinfestation for agricultural areas adjacent to these timber reserves or the prevention of greater damage to forage crops on the range can never be estimated. Estimates have been made by numerous investigators that from 15 per cent to 25 per cent of range value is depleted which, if true, means that an enormous saving to stock men would be effected, not to mention the slightly increased revenue to the forest service from additional grazing fees. It was not until 1917, however, that the bureau of biological survey took up extensive educational campaigns in connection with the county horticultural commissioners, in order that the co-operative action gained thereby might furnish a means by which all public and privately owned lands could be cleared of squirrels in a systematic manner.

Every effort was made by the United States Public Health Service to procure co-operation of all counties where plague had been found, as well as some adjacent, especially in a financial way. Boards of supervisors were petitioned to establish an inspector system, which for the most part met with approval of these officers. They had been burdened with the details of eradicating squirrels in their counties from an economic angle and now comes an opportunity to unload some of these duties upon a willing federal agency whose purpose had behind it the safety of human lives.

The plans upon which extensive campaign measures were instituted by the public health service were very sound to start with. The camp established to create a squirrel-free zone about Oakland, Berkeley and Alameda served as a training camp for new men. Life histories, habits and control measures of squirrels were taught to those needing such information before starting into the field. Many of the employees had seen military service during the Spanish-American War, hence the establishment of camps upon a semimilitary basis was not at all difficult and the men seemed to take to the procedure in a very satisfactory manner. The last half of 1911 saw an augmentation of the field force which resulted in the cleaning up of many acres of land. Every effort was made to keep the bay cities in a rapidly improving condition by

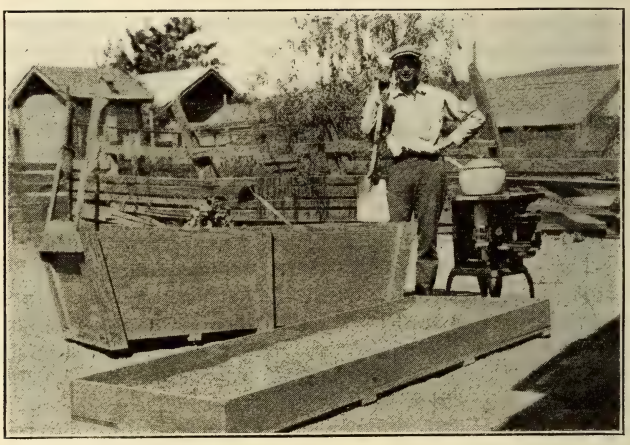

FIG. 53. A type of mixing box for small batches of poisoned grain. Type of drying tray and shovel used in mixing is shown.

not allowing rats to become infected by fleas from squirrels, by means of the formation of the Alameda-Contra Costa Squirrel-Free Zone. A second zone, called "squirrel-free," was established in the region east of the San Joaquin River to prevent spread throughout other parts of California as well as to the East. Foci of plague infection received special attention from the crews operating at the time and from the persistent attitude displayed, great possibilities were anticipated. A great many counties, about twenty, were covered in whole or in part up until the close of 1911, but unfortunately depletion of the appropriation caused a suspension of active work in all but four counties in which there was immediate danger of the plague spreading if vigilance in any way was relaxed. In the four counties, San Joaquin, Contra Costa, Alameda and Santa Clara, the concentration of all men from the many counties pointed toward an effective country-wide cleanup, inasmuch as smaller inspection districts could be allotted those engaged.

By the end of 1913, the maintaining of a squirrel-free zone in Alameda and Contra Costa counties was discontinued, the plague cases were rapidly disappearing and all indications pointed toward a cessation of activities by the end of 1914. Some of the counties still continued to contribute sums ranging from $200 to $500 per month, which amounts

were to be used for traveling expenses of men whose salaries were provided by the public health service.

As the extensive field operations contemplated could not be carried out quite as per schedule, more time was devoted to conducting experiments in control methods. Experimental work covered tests on poisoned grains to a limited extent, but mostly on the noxious gases. From the farmer's viewpoint poisoned grain was sufficient to insure against a heavy crop loss, but it was seen that in order to extend operations over the entire year, the gas methods must be perfected. The officers in charge tried out the numerous gases, as well as machines which had been devised to force the gases throughout the ramifications of the average ground squirrel burrow. There were enough men in the field properly to test the efficacy of the dosages recommended, also the comparative efficiency of the different mechanical contrivances which insured proper distribution of the gases. The squirrel destructor perfected by one of the officers of the public health service, using carbon disulphid or some of its proprietary mixtures, seemed to work out most satisfactorily, hence was adopted. A few years later the waste-ball method was so systematized as to compete favorably with the destructor both as to economy of labor and costs.

In addition to experimental work time was taken during a short period for perfecting efficiency records and charts, and computing the economic benefits to be derived from squirrel eradication. Field men were supposed to come up to a certain charted efficiency, which had been computed on the basis of past records. The checking up of the efficiency of operations, the extent of action in the various counties, the exact knowledge obtained by the officers in charge as to proper control portended most favorably for the work. Plague-infected squirrels were scarce, demonstrations had proven that zones approximately free from squirrels could be produced, co-operation in many cases had been lined up, the centers of population had been protected, the east San Joaquin had been combed for squirrels to such an extent that only one specimen per day was a good record for a hunter, and it was even stated that the five foci of plague infection among squirrels would be stamped out by August, 1914. The nature of the disease was not so well understood as to uphold such a prediction, and it has been learned that even to date the spread of bubonic plague among squirrels has not been stamped out. The plague laboratories were perfecting the then known methods of diagnosing bubonic plague and were conducting many controls in determining new features about the disease.

Without more direct supervision in the field some of the inspectors became automatic report writers, commenting upon their work differently than actual cases proved same to be, hence the supervising inspector and the officer in charge was not always apprised of actual conditions.

At no time have squirrel-control measures assumed such proportions as did those undertaken by the public health service co-operating with the state board of health, nor is it likely that the annual expenditure of funds under the direction of a single agency will soon approximate the amounts spent by this federal service. In the counties where the work was performed an untold amount of good was accomplished, encountering only the drawback occasioned by a lack of funds with which to follow the work to a successful conclusion. The work has at

this writing resolved itself to an intensive "scouring out" of bubonic plague foci at which points eradicative measures are immediately inaugurated until all danger of dissemination is eliminated. No intention of conducting an immediate campaign over wide areas is now entertained.

### LATER CAMPAIGNS AND METHODS PURSUED.

That state-wide action of some sort was necessary in 1916 was evidenced by the presence of six bills before the legislature in the spring of 1917. The state board of health law in so far as squirrels were concerned was merely an amendment to a law intended to facilitate the payment of claims for liens. From the economic viewpoint this law did not meet the need of the agriculturist. Most of the remaining were little better than pre-existing acts allowing boards of supervisors to appoint inspectors or pass ordinances. An absolutely new form of procedure was embodied in the amendment to the County Horticultural Commissioners Act of 1917, which landed as a boomerang for the squirrels. This particular law had met all tests in the courts with remarkable stolidity; hence, to embody the control of squirrels or other rodent pests, amounted to much the same as recognizing the squirrel as a thing to be controlled just as were insect pests and plant diseases. As a matter of fact the extensive work of the public health service and the United States Department of Agriculture had demonstrated this to be possible.

The horticultural commissioners were established in counties from one end of California to the other. They were bound together in a more or less loosely organized association, over which the State Commissioner of Horticulture presided, much after the fashion of an adviser and director. To be sure, no legal connection obtained between state and county commissioners, but the influence of the state horticultural commission could be felt strongly throughout the counties. Prior to the passage of the law certain of the county commissioners, observing the trend of action, took upon themselves the burden of demonstrating the possibilities to be afforded by engaging in work of benefit and interest to both agriculturists and horticulturists. The activities of their office could be placed before a great many more people than had been the case heretofore, and the more wide-awake commissioners lost no time in taking up their new duties. A great advantage of this early work was found in the realization that there was no need to delay matters after the law finally became effective July 27, 1917; it was one of the biggest means whereby a horticultural commissioner could show the residents and supervisors of his county whether he was "marking time" or whether the interests of the community were uppermost in his mind in fulfilling the duties of his office.

It can be hoped that county horticultural commissioners, who can have everything in their favor to make their campaign a success, will not allow their activities against ground squirrels to become sporadic. To be sure, each commissioner has his own ideas as to how he may proceed best, and wherever anything extensive has been done, the work has proved remarkably gratifying; still there remain some counties where county horticultural officers have started work but relaxed in

their vigilance. Right now every county that has immediate prospects for a good control of its rodent pests has had a thorough educational campaign and has established the handling of poison supplies on a firm basis (Fig. 46). The county officer in charge in some cases has turned the work over to his deputy commissioner, who, if a man trained in rodent control, will likely be more successful than the commissioner in properly executing the duty imposed by the County Horticultural Commissioners Act.

If the centralization of the many duties of all these fifty county horticultural commissioners could be obtained by placing one leader in charge, far greater general efficiency can be expected. In this day of standardization, results commensurate with the amounts expended by county horticultural officers can be looked for more expectantly when they report to one chief. This is a general statement, and, of course, has exceptions. The present independence of the county commissioners has shown what can be accomplished by men of high caliber, hence it follows that what can be done by one county horticultural commissioner ought not be considered more than a reasonable attainment by the remaining.

County commissioners of horticulture were not experts in rodent control work. They were so scattered from one end of California to the other that to make their common needs felt would necessitate the establishment of a bureau for disseminating suitable educational matter and bringing together co-operative agencies, many of which could render invaluable aid.

To fulfill such a requirement the State Commissioner of Horticulture organized in his office a Rodent Control Division, the duties of which are outlined elsewhere. Of what value this division was in assisting the county officials to perfect their technique of dealing with their new duties can not be fully realized at so early a date. However, it can be said that such value depended largely upon the amount of use these men would make of the division. An important phase of the activities of such an office would be the relieving of complaints filed against the infestations of rodents upon state and government lands. The Bureau of Biological Survey was handling the latter in very good fashion; still handicaps by lack of funds were being confronted. By a co-operative agreement exchanges of operations could be made whereby duplication would be eliminated. In exchange for work on government lands the Rodent Control Division received the word that state lands would be attended to in localities where this federal agency was engaged. In consequence county horticultural commissioners knew that they could overrule the complaints that federal and state governments were doing nothing. Hence, attempting control of rodent pests of economic importance upon state lands in California was one of the prime tasks confronting a newly organized Rodent Control Division. One most essential step to bring about a control was first to learn of the situations of the areas in question, then to ascertain in detail the amount of infestation to proceed against. Field assistants followed maps prepared at headquarters giving the location of such areas which they were to seek out for control operations, often being called upon to resort to pack animals to reach the remoter regions when on this reconnaissance work (Fig. 47).

The general condition in so far as infestation was concerned was carefully mapped, and a card showing a township square had space for comments upon general accessibility of the area, proximity to agricultural land, to supplies, and recommendations for methods to pursue.

After having determined upon the means of procedure, it followed that materials for proper operation must be gathered. Variable conditions made it necessary to attack in different ways. In the case of the Oregon ground squirrel, whose period of hibernation extends well into February, the need for action is most necessary immediately after its first appearance in the early spring. Presence of snow (Fig. 48) might occasion delays in getting on to the ground, but fortunately this was not the case in 1918, when a dry winter allowed early operations in northeastern California.

Inasmuch as all of the work must be done afield fairly uniform means could be outlined by which action could be taken. If, in general instructions to field assistants, the methods desirable under certain conditions were outlined, an efficient piece of work might be done. Generally speaking, if the area was small the assistant could handle it himself without hiring men, but where the needs entailed the hiring of two or more men for a considerable period of time, a camp was established from which the crew would operate. If a piece of state land was located in a rather remote section, a small roving outfit would look after it, utilizing pack and saddle stock. Where the area concerned was of considerable size, and several days or weeks labor was involved, the plan of operating brought field men ahorse with poisoned grain bags hooked to the saddle horn (Fig. 49), riding abreast in cavalry style. Horseback affords the best means for such work, giving the poisoner a greater range of vision; also allows for a far more suitable distribution of the grain on the ground by scattering. Grain for poisoning generally was prepared at the county seat, where the county horticultural commissioner was engaged in mixing poisoned grain, and hauled by the field assistant to the camp. If unhandy to do this a rough box was constructed to care for mixing of small quantities at a point not far from the base of operations. Grain usually could be had close at hand with the only disadvantage that it was often dirty and full of weed seeds, thus calling for recleaning.

If a body of land needed treating which would take several days work by one man, a rancher in the locality could be hired to look after this when furnished with all necessary supplies by the field assistant in charge. If a base camp could be established from which several parcels of land might be worked, handling of supplies was facilitated by pack train (Fig. 50).

When these lands were being cleaned up the county horticultural commissioner enforced the control of rodents on adjoining areas, and often it was necessary to hold one or more community meetings to apprise the residents of the contemplated work, even though a series of educational meetings had been held at an earlier date. After a series of such educational meetings (see Monthly Bulletin, California State Commission of Horticulture, Vol. 6, No. 9, September, 1917) had been conducted in a county the horticultural commissioner practically bound himself to arrange for the distribution of supplies to carry on control work against rodents. At the time of the meetings the plan of handling

such supplies was presented to those attending. In a county where the centers of population were scattered and no organization existed, the residents signed up their needs and a community poison mix was held (Fig. 51).

Where the county horticultural commissioner was allowed the services of several inspectors a central mixing depot was established for the whole county and from here the inspectors carried the preparation to those desiring same in their respective districts. A variation of this scheme was to have a central point for mixing the poisoned grain, from which it was shipped to stores throughout the county. Stores were allowed the slightest possible sum for handling the grain. In cases where the amounts handled were large the average-sized batch of poisoned grain mixed was six sacks, for which a specially constructed mixing box was made. Both shovel and mortar hoe were used in turning the grain, and enough of these boxes were built to allow for drying the grain right in the bins (Fig. 52). Tulare County handled about one hundred ten tons of poisoned grain in this fashion in the course of a year following August, 1917. Where the output was not so great, still calling for continuous preparation of the grain, a smaller bin was found most handy (Fig. 53). This is the commonly used box for two or four sack batches. All of the turning of the grain is handily done by a square-pointed D-handled shovel, thereby insuring an absolutely uniform mixture. That time be saved in mixing grain, drying trays were provided which held two sacks comfortably and which allowed for proper drying of the product. There is little to say in favor of one type of mixing bin over the other. Each commissioner stands up for the type which he is using, consequently both might be considered satisfactory. Of the methods of distribution that by inspectors seems to have proved the better, inasmuch as the amount allowed a storekeeper is eliminated and the inspector for the district has a better check on the amount of poisons being used in his district as well as having an indication of the interest being displayed. Many counties had farm bureau organizations which handled poisoned grains gratis in an effective manner. In some instances the farm bureau looked after the mixing of the product in co-operation with the county horticultural commissioner, distribution still being handled through the farm centers. The wholesale handling of poisoned grain by horticultural commissioners as well as the distributing of carbon disulphid during the winter months amounted to a good publicity campaign. In some counties the commissioner was well known to the fruit growers but not to the majority of farmers, hence the squirrel work brought him in contact with all. He was in charge of a county office already established to carry out the mandates of the act, hence no new appointments need be made. The officer in question also had been in the county for some time—it was his home—consequently he should have the interests of the community at heart. Furthermore, he was a county officer expending funds in the control of rodents under the supervision of the board of supervisors, and no outside agency, either state or federal, had any direct interest in the expenditure of the funds appropriated.

It was clearly a matter for the county horticultural commissioner to undertake. Some of these officers regarded the rodent amendment to be considerable burden as it actually proved itself in a few of the

counties; however, all voted in its favor when brought before them in convention. The possibility of procuring additional funds from the Boards of Supervisors appeared to be a problem; however, in most cases the work of the commissioner had commanded the interest and respect of the supervisors to such an extent that there was no great hesitancy to set aside funds for such necessary work as ground squirrel control. A sound policy was usually outlined and adhered to by the commisisoners consisting generally of the establishment of a revolving fund for the purchase of poison supplies in large lots for preparing poisoned grain as cheaply as possible and a systematic campaign by districts to clean up lands of negligent owners. Payment of bills for enforcing the abatement of the squirrel nuisance was paid from the general fund which was reimbursed upon the collection of liens.

Naturally opinions as to proper means of procedure under the law differed with counties, hence if a uniform program could be adopted great good would come of it. At the convention of county horticultural commissioners at Sacramento in November, 1917, the attorney general for California appeared before this body and answered as many questions as had been submitted to him in writing previous to the meeting as well as several asked verbally. This official cautioned the commissioners as to proper use for the law entrusted to them. It should not be used as a threat but should be so judiciously enforced that the farmer would consider the enforcement a benefit rather than a burden.

Some commissioners had followed the plan of sending legal notices to all landowners without any particular warning excepting an occasional newspaper notice. Others took pains that all should be fully informed as to the legal requirements and best methods of control. This latter method gave personal acquaintance with a majority of those who would be interested enough in squirrel control to serve as disseminators of proper information, thereby avoiding the service of many notices. Inspectors who had been called together and given a detailed set of instructions as to properly serving notices and in methods of controlling rodent pests were found to produce a good feeling among the landowners, consequently better results were noted.

To take a portion of a county for purposes of rodent control, and systematically work such a district, proved to end in a more promising way than in cases where sporadic work was attempted all over a county or where merely the complaints of landowners adjoining an infested area were looked after. Systematic control operations without skipping plots has certainly saved time and labor. Fortunately, proper control methods have resolved themselves to two for the year, namely, poisoned barley for the dry season and carbon disulphid for the wet; hence a proficient inspector can develop a trained crew of men to conduct this work in a short time.

Unsettled labor conditions due to the war have, of course, handicapped the work an untold amount during 1918, inasmuch as rates of pay for laborers could not be placed high enough to attract men of the ability desired. Good mechanics and shipyard workers were developed out of numbers of men whose inclinations prior to this time had kept them satisfied to remain in rural communities. Squirrel work never paid any more than the average farm hand was receiving.

Costs of operations by the horticultural commissioner necessarily carried with them a greater overhead than same would if handled by the landowner himself. Abstracting the land, service of notice, inspection of the degree of infestation, a number of times perhaps, hiring men who may be inefficient or untrustworthy, transportation of crews from place to place, all had to be charged somewhere, consequently the landowner had them to bear if all these procedures were carried out. It has been surprising to note the claims by large farmers that costs to them were exorbitant, yet when properly served with a notice and given opportunity to do their own work, or give good reason why it should be delayed, they absolutely ignored the notice of the commissioner. After the bill was presented, the complaint could be heard

U. S. Public Health Service crew at work killing ground squirrels by use of carbon disulphid and pump invented by Passed Assistant Surgeon John D. Long, U. S. Public Health Service. (Courtesy State Board of Health.)

from one end of California to another. In the more progressive counties no anxiety was felt by the commissioners over the collection of bills, for the district attorneys would put the lien proceedings over in a short time. All phases of this all-important food conservation problem rests in the hands of one official, who at the same time can govern, in a large measure, the horticultural prosperity of his county.

A better plan for the complete control of ground squirrels in California can hardly be wished for than the one made feasible by the horticultural commissioners act. In the first place it is state-wide, and has as a basis economic benefits to every farmer, and rancher in the state. If properly informed there is not a single agriculturist but who must favor the control of this pest for his own profit. Persistence in effort, concerted action by all officers, can result in a saving of millions in foodstuffs for California. The greatest state-wide campaign to eliminate rodent pests has been started; may the anticipated results be realized within a period of time such as to make the achievement thereof noteworthy.

# A STUDY OF FUMIGATION METHODS FOR KILLING GROUND SQUIRRELS.

By JOHN S. BURD and G. R. STEWART.

## INTRODUCTION.

In the problem suggested by the title, two general methods may be used: (1) Applying a given method in squirrel-infested areas and observing its apparent effects in decreasing the number of animals; (2) Working with individual animals to determine their susceptibility to the fumigant, the time necessary to kill, and other conditions necessary to bring about the desired result. The first method will not furnish a very exact determination of the percentage of squirrels killed; however, it does meet a very practical condition, namely, that it complies with conditions actually existing in the field. So many statistical studies concerning the general effect of fumigants have been made by the first method that it was felt that the best procedure was to follow the second method, and it may be of interest to readers of this publication to learn of the results obtained in the application of such a method.

## VALUE OF CARBON DISULPHID AS A FUMIGANT.

Because of the well-known practical value of carbon disulphid as a fumigant, we have devoted considerable attention to a study of its effect on squirrels, both in the exploded and unexploded condition. We have found that 2 per cent of carbon disulphid in air kills a normal animal in somewhat less than 20 minutes, and that a greater strength does not seem to be proportionately more effective. This means that if the animal can be kept in contact with the 2 per cent gas for 20 minutes, death may be expected. If it is practicable to bring the animal in contact with the gas at all, the maintenance of this strength for 20 minutes is quite feasible. A strength of 1 per cent carbon disulphid does not normally kill animals in less than one hour. During the course of an hour it is to be expected that there is much greater opportunity for the gas to escape, so we have no hesitation in stating that a much higher efficiency will unquestionably be obtained if 2 per cent gas is used for 20 minutes, than if attempts are made to use a 1 per cent gas and hold it for a longer period. All of these statements apply to unexploded gas both in closed containers and artificial burrows.

We have obtained practically the same results with the exploded carbon disulphid when the animals were kept in closed containers. The reason why the exploded gas acts the same as the unexploded gas is clear from a chemical study made by us. When the carbon disulphid is exploded there is formed a comparatively large volume of sulphur dioxid which is less poisonous than is the original carbon disulphid. On the other hand, a small proportion of carbon monoxid is also formed when carbon disulphid is exploded. Carbon monoxid is highly toxic, and apparently it is sufficiently toxic to compensate for the fact that some of the carbon disulphid is changed to sulphur dioxid.

Thus it is immaterial whether the carbon disulphid is exploded or not, provided the gases reach the animal. Experiments with artificial burrows where the vaporized gas or products of explosion have to travel considerable distances before reaching the animals indicate that effective work depends largely (1) on the shape of the burrow, (2) the relative elevation of the squirrel and (3) the point of application of the fumigant. That is to say, carbon disulphid gas will flow readily on the level or down hill. It will not, in either its exploded or unexploded form, rise over an elevation of even one to two feet, unless driven by some form of pump or compressed-air apparatus.

Our conclusions with reference to the question of "exploded versus the nonexploded gas" is that it makes very little difference. Under some circumstances there may be a slight advantage in favor of the exploded, since the force of explosion tends to disseminate the gas somewhat more quickly, but, in so far as our observations go, under any conditions we have been able to provide, there is practically no choice between the two methods. Furthermore, either or both methods may fail unless some form of pump is used to disseminate the gas. Any form of pump which will distribute adequately either the exploded or unexploded gas should be effective.

### EXPERIMENTS WITH GASES OTHER THAN CARBON DISULPHID.

We have tried a number of other gases which are sometimes used or which naturally suggest themselves because of their toxic properties. Among these is chlorine, which is effective but difficult to use because of its corrosive qualities. It is hardly likely, however, that the use of chlorine would be less expensive than carbon disulphid, which is known to be effective.

Gasoline is not nearly so effective as carbon disulphid. Two per cent gasoline vapor will kill animals in about 50 minutes. The explosion of gasoline apparently does not give off a highly toxic gas. Our figures indicate that the cost of killing squirrels is hardly likely to be less by this method than when carbon disulphid is used and owing to the longer time it takes to kill animals would probably prove less effective.

Carbon tetrachlorid appears to kill animals in about 40 minutes, but is more expensive than is carbon disulphid.

Sulphur dioxid, formed by burning sulphur, appears to kill in about 40 minutes. This is twice as long as the time required by an equal percentage of carbon disulphid.

The gas known as arsine, generated by the decomposition of calcium arsenide with water, appears to be quite effective. We were unable unfortunately to obtain sufficient amounts of this material to carry out conclusive experiments. There is some reason to believe that it might be as effective and cheaper than carbon disulphid. It has one disadvantage, however, in that it is highly poisonous to man. It is possible that further studies may indicate sufficient superiority on the part of this substance to justify recommending its use.

### CONCLUSION.

Our general conclusion in these experiments is that good results may be obtained always by using 2 per cent carbon disulphid in air.

This corresponds to 1½ to 2 ounces of the liquid carbon disulphid when mixed in the air of a fairly large burrow. With smaller burrows some of the carbon disulphid is doubtless wasted, but burrows probably seldom occur of sufficient size to justify using larger quantities. It seems clear that the usual procedure of 1½ to 2 ounces is likely to be the most effective in the sense that it will kill squirrels at the minimum expense per animal. With the possible exception of the arsenic compound mentioned above it is extremely unlikely that any of the other substances experimented with can effectively displace carbon disulphid, but that carbon disulphid should be used in connection with some form of pump which will insure maximum dispersion of the gas throughout the burrow.

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## AMMUNITION USED BY 4-MINUTE MEN, DURING "SQUIRREL WEEK," APRIL 29th–MAY 4th, 1918.

The State Commission of Horticulture, through its Rodent Control Division, is endeavoring to bring together all organizations that can be of assistance in squirrel control. Why? Because it always takes continual work, concerted action, systematic effort and community co-operation to accomplish the best results.

The BEST squirrel is the dead squirrel.

On an average, ground squirrel destruction to agricultural crops in California amounts to $1.00 per acre. In instances it amounts to as high as $10 per acre.

The Hotel California board bill for ground squirrels in 1917, estimated by the United States Biological Survey, was $30,000,000—yet unpaid.

The ground squirrel is admitted in many counties to be its worst crop pest.

Are you not willing then to give your whole-hearted support to this state-wide movement to KILL THE SQUIRREL?

We farmers pay higher taxes to the ground squirrel than to the assessor.

The value of food products destroyed by the ground squirrel in 1917 exceeds the gold productions by eight millions.

There are 100,000,000 acres in California. Each one, on the average, has a ground squirrel who does not live on thin air. If each one cost one cent in two weeks to feed, we pay an annual board bill of $30,000,000. That will keep 40,000 families in food for a year.

The other fellow knows that your squirrels are worse than his. Are you in the same boat?

Don't let George do it. He will fail you every time.

The squirrel does not recognize daylight saving. He uses it all.

He harvests crops as soon as they are put in the ground and keeps at 'em. We must keep at him.

He preys on our crops in countless hordes. He fills the ranks of the killed in true military fashion.

We hear from one end of California to the other—lost 20 acres of almonds; no grain for the first six rounds in my 160 of barley; 7000 young trees destroyed before the buds came; ditch washout cost us $2000; 256 barrels of oil down the wash over night. Can we let this continue? Not if we have good reason.

Why hesitate? We can get 'em. How? Poison 'em, gas 'em, drown 'em, shoot 'em, trap 'em, submarine 'em.

We must work as efficiently as the ground squirrel in order to combat him effectively.

You do not know how to do it? Well, just call for advice and assistance from the State Rodent Control Division, State Commission of Horticulture, at Sacramento, and from your local county horticultural commissioner.

There are a number of ways of killing the ground squirrels. Either of these organizations will tell you the best method to suit conditions at the time.

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FIG. 54. Habitat group of the California Wild Cat (Lynx eremicus californicus).

## THE WORK OF THE RODENT CONTROL DIVISION.[1]

By S. V. CHRISTIERSON and C. A. WILKINS.

For many years, in fact throughout the history of California, we find mention made of the damage occasioned by the ground squirrel. Various laws have been enacted in the past to suppress this plague, but all of them are now matters of record only, and have sunk into obscurity. But the damage by the genus Citellus has assumed more and more alarming proportions each year, as the agricultural lands of California have been developed, and the natural enemies—coyotes, bobcats (Fig. 54), hawks, owls, weasels, skunks and snakes—wantonly destroyed or driven off to more inaccessible places. Several agencies such as the State Board of Health, the United States Public Health Service, the county boards of supervisors, and others have on certain occasions given valiant and effective service in different localities to eradicate the ground squirrels, but due to lack of co-operation, funds and general effort, throughout the state, no lasting results were obtained.

To effect an organization, state-wide in scope, for this purpose, would seem hardly advisable, especially as such an organization already existed, for the purpose of protecting the horticultural and agricultural interests of the state. The county horticultural commissioners had been able for years to eradicate, control or destroy insect pests and fungous diseases injurious to the state of California, by requesting an eradication, through the service of a notice to that effect upon the landowner, and if he failed to comply, having authority to do so at county expense. Such expenses for eradication of public nuisances, if done at county expense, becoming a lien against the property.

At the convention of the State Association of County Horticultural Commissioners at Napa, in November, 1916, the newly appointed State Commissioner of Horticulture placed the question of a state-wide campaign against the destructive ground squirrels squarely before these officials. By asking for a vote as to how many of the meeting would favor a legislative measure placing this important work in their hands, it was found that the commissioners with only one exception were willing to support it. Accordingly, the legislative committee of this body immediately proceeded to amend the statutes governing the actions of the county horticultural commissioners so as to include the destruction of ground squirrels with their other manifold duties. This amendment was introduced in the legislature of 1917, and in the face of much opposition (four other bills dealing with ground-squirrel eradication being presented at the same time) passed both houses, with hardly a dissenting vote, and was signed by Governor Wm. D. Stephens on May 17, 1917. The only reason for this was the advantage, which the legislature immediately discerned, of an already perfected, state-wide organization, which, instead of localizing the work, would generalize

[1]Historical data frequently are lacking on subjects of state-wide interest. This article has been prepared to supply authentic information concerning the Rodent Control Division of the State Commission of Horticulture, causes leading up to its inception, organization, and in a condensed form, the work accomplished during the year 1918. To make this a matter of permanent record, this article is being published in the Rodent Issue of the Monthly Bulletin.

FIG. 55. Habitat group of the California Ground Squirrel (Citellus beecheyi beecheyi).

FIG. 56. First of the series of posters issued by the Rodent Control Division during the Spring Squirrel Drive.

# GOV. STEPHENS

## PROCLAIMS SQUIRREL WEEK

## APR. 29 - MAY 4

# MR. HOOVER

wires:

"KILL THE SQUIRRELS---
food is needed for our
armies and the Allies."

## WILL YOU HELP?

**ASK Your County Horticultural Commissioner HOW**

**STATE COMMISSION OF HORTICULTURE** G. H. Hecke, Commissioner

RODENT CONTROL DIVISION, W. C. Jacobsen, Superintendent SACRAMENTO, CALIFORNIA

FIG. 57. "Squirrel Week" received recognition from the state's chief executive, and from the U. S. Food Administration. Food production and conservation naturally means squirrel destruction.

it and make it effective from Siskiyou County to San Diego County. This act provides for (1) inspection of property, and if found infested (2) service of notice to eradicate, control or destroy the ground squirrels to the satisfaction of the county horticultural commissioner; (3) if notice is unheeded, declaration of ground squirrels to be a public nuisance, and making it mandatory upon the county horticultural commissioner immediately to destroy such nuisance at county expense; (4) placing of lien against the property, and collection by the district attorney to satisfy costs, such lien to take precedence over any other lien with the exception of taxes.

Several of the county horticultural commissioners in whose counties the squirrel infestation was particularly heavy, hence causing a great deal of damage, interested themselves in control measures long before the law went into effect on July 27, 1917. This was desirable as well as necessary, as they naturally were supposed to know something about the pests they were fighting as well as the most approved methods of combating them. Through the courtesy of the United States Biological Survey, the California representative of the bureau was detailed for this work and with his assistance several county horticultural commissioners started active campaigns against ground squirrels shortly after the law became effective. These were originally of educational nature to acquaint landowners with methods of control, preservation of natural enemies and the mixing of poisoned baits. These campaigns in most cases have been followed up by rigid enforcement of the law by these commissioners.

Generally speaking, the campaigns in the different counties followed the same outline. Previous to the series of meetings to be held, large colored posters announcing the beginning of an active squirrel campaign, plans of the meeting and dates of the meeting places, were displayed all over the county. At the meetings, the county horticultural commissioner explained in detail the intents and workings of the new law, and the federal representative delivered a lecture on the ground squirrels of California, their habits, economic importance, natural enemies, and most recently adopted methods of control. The first of these campaigns was held in San Luis Obispo County.[1]

A great deal of difficulty was encountered in enforcing the law on properties adjacent to government and state land. The Biological Survey assisted greatly with the government land, but no one had jurisdiction over state lands; thereupon the State Commissioner of Horticulture, observing the trend of events, on January 1, 1918, secured a $40,000 emergency appropriation from the State Board of Control, with the approval of Governor Wm. D. Stephens, of the $1,000,000 war emergency appropriation made by the state legislature in 1917, to be used at the Governor's discretion. This appropriation to be utilized (1) as a food conservation measure to assist in controlling the ground squirrels, annually destroying $30,000,000 in food products and crops in California; (2) to assist the county horticultural commissioners in systematizing and co-ordinating their work in rodent control; (3) to eradicate ground squirrels on state and school lands in California; (4) to establish a central rodent bureau to be known as the "Rodent

[1]See Monthly Bull. State Comm. Horticulture, Vol. VI, No. 9, Sept. 1917.

FIG. 58. Results obtained from a 3-pound can of poisoned barley scattered near grain field early one evening, the dead squirrels being picked up the next morning. Poisoned grain is *effective,* if *mixed right* and distributed properly. (Photo, Wm. Gould, Yolo County Horticultural Commissioner.)

FIG. 59. A strong appeal was made to the farmers to kill the squirrels this year, both from a patriotic and financial standpoint.

Control Division of the State Commission of Horticulture." Results obtained by this arrangement have demonstrated the advantages of co-ordinating the work of the various agencies in fostering the upbuilding of California's great horticultural and agricultural interests, by placing the control of rodent pests under the supervision of a well-organized division, through which that particular phase of development might be brought about with the greatest economy in funds and labor, and with substantial results, to the state as a whole.

The United States Public Health Service for years has waged active campaigns on ground squirrels in counties about San Francisco Bay, as

FIG. 60. Habitat group, Oregon Ground Squirrel (Citellus oregonus).

a measure of protecting the population against bubonic plague, which through diagnoses in 1908, was found to be carried, through the medium of fleas, by ground squirrels. This federal service had been able, through co-ordination of effort through a central executive office, to accomplish a greater amount of control work than had any other agency heretofore.

The appointment of W. C. Jacobsen as superintendent of the Rodent Control Division by action of the State Commissioner of Horticulture, met with approval by the county horticultural commissioners, due to the interest taken in assisting these county officers with his experience acquired in conducting operations against rodents in some of the western states. S. V. Christierson, county horticultural commissioner of San Luis Obispo, through civil service examination, was named assistant superintendent, and with the assistant secretary, C. A. Wilkins, has charge of the main office of the Rodent Control Division in Sacramento.

Since the organization of the division in January, 1918, educational campaigns have been conducted by the Rodent Control Division in

FIG. 61. Poster used in shop and store windows throughout the state.

Tehama, Stanislaus, Siskiyou, Monterey, Napa, Sonoma, Humboldt and Lake counties, and by the United States Biological Survey, co-operating with the division in Merced, Modoc, and Shasta counties. Such campaigns were held upon application from the horticultural commissioners of these counties, and proved a great help to them by informing the farming population in these counties as to best methods of controlling ground squirrels and other injurious rodents and in aiding their work of protecting the agricultural and horticultural interests of California. Co-operating with the Rodent Control Division and the United States

FIG. 62. Habitat group, Douglas Ground Squirrel (Citellus douglasi).

Biological Survey, the farm advisers and farm bureaus of the University of California's excellent extension system, have done and are doing splendid work in assisting the farmers. That such campaigns have fully justified the efforts of these agencies, is attested by the several horticultural commissioners, who state that their subsequent success largely has been due to the educational features of the meetings.

Following these campaigns, the Rodent Control Division in the month of March asked the 48 county horticultural commissioners for their active support in carrying on a voluntary spring drive against the ground squirrel. This plan was at once welcomed by them, since in

the past individual effort at cleaning up in the different counties had met with only partial response or absolute failure. To accomplish the object of the drive with the least possible delay, the press of California was requested to co-operate, and to them is due in a large measure the success of the project. They gave liberally of space to advise the rancher of the voluntary drive, to advise of control methods and of the law under which the county horticultural commissioners are empowered to act. The State Commissioner of Horticulture and the Rodent Control Division are indebted to the press for its assistance.

A series of colored posters urging the ranchers, both from a financial and a patriotic standpoint, to kill the squirrels were issued and

FIG. 63. Habitat group, Sierra Golden Mantled Ground Squirrel (Callospermophilus chrysodeirus chrysodeirus).

distributed by the division to county horticultural commissioners. These were posted by the county inspectors and others interested in the drive.

As a further means of assuring success to the campaign, the school children were asked to co-operate, rewards of cash prizes being offered by the State Commissioner of Horticulture personally, and by various county chambers of commerce, supervisors and other organizations. Squirrel week, April 29 to May 4, was planned and a proclamation issued by Governor Wm. D. Stephens, calling upon everyone to do his utmost to destroy this pest. "Squirrel Week" had the moral and financial backing of more than thirty organizations, including the State Council of Defense, the county councils of defense, the United States Public Health Service, the Biological Survey, United States Forest Service, the University of California, through the farm advisers and farm bureaus, the Museum of Vertebrate Zoology, the Insecticide and Fungicide Laboratory of the University, the railroad companies of Cali-

fornia, and many chambers of commerce, boards of trade and similar institutions.

Herbert Hoover, United States Food Administrator, endorsed the campaign in a telegram to the State Commissioner and called upon the citizens of California to destroy the ground squirrel so that food might be had in abundance for our armies abroad and for those of our allies.

It was not anticipated that the voluntary drive and Squirrel Week would be all child's play, but it was believed, and further development has justified the belief, that the entrance of school children into the fight would awaken interest among the parents, those whom the government expects to aid in producing this increased food supply.

FIG. 64. Habitat group, Long-eared Chipmunk (Eutamias quadrimaculatus).

The final report of this contest ending May 4 accounted for the destruction of more than 100,000 ground squirrels, and without question thousands more were destroyed but no evidence collected. Many squirrels died in their burrows, many more were killed with suffocating gases, so the real losses, in so far as numbers are concerned, never will be known. The increased yield in every section of the state where ground squirrels had been active in years past, is mute evidence of the success of this voluntary drive and school contest.

In many counties the contest among school children was continued for an indefinite period and in fact all along the line there is no sign of failing interest. Lassen County, for instance, unable to participate in the contest in May, late in July reported that as a result of the school children's contest, 31,669 ground squirrels had been accounted for, one school district reporting 8,089, and an individual pupil exhibiting 3,780 squirrel tails as evidence of destruction. Mr. Taylor, county

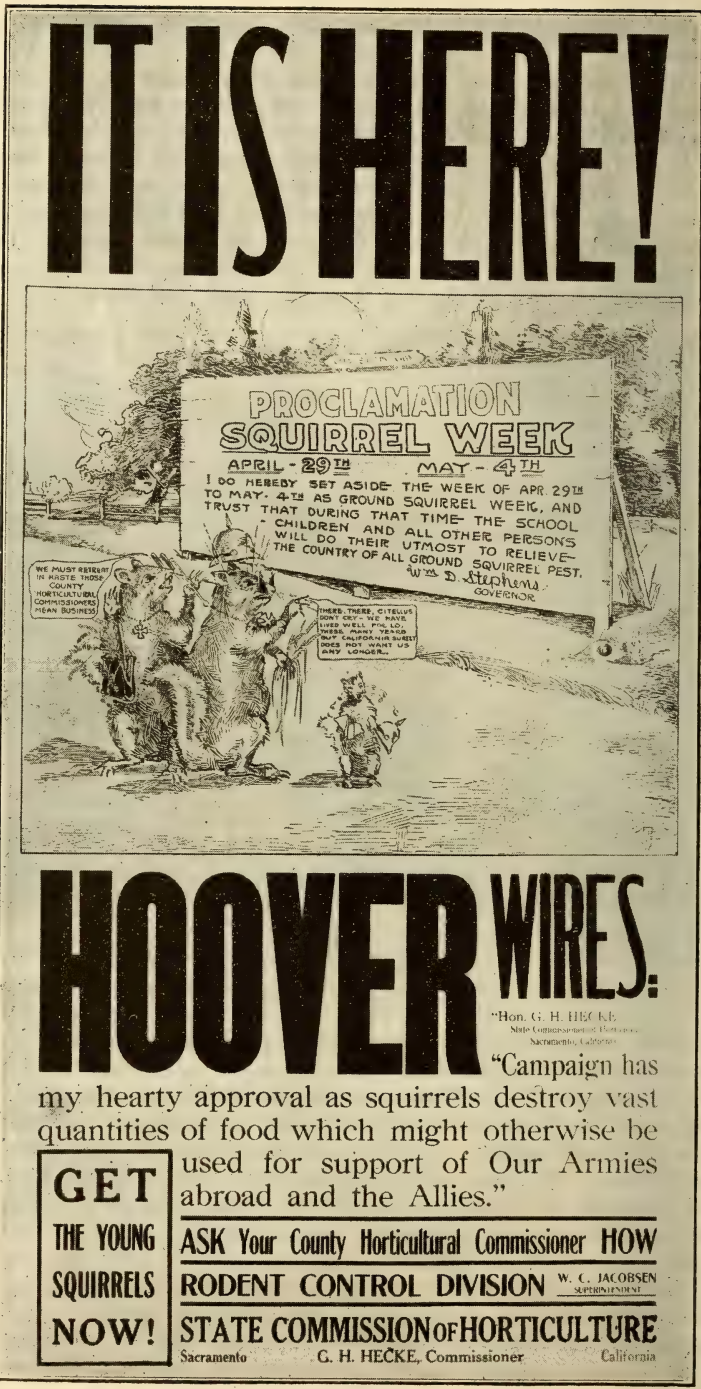
IT IS HERE!
PROCLAMATION
SQUIRREL WEEK
APRIL - 29TH MAY - 4TH
I DO HEREBY SET ASIDE THE WEEK OF APR. 29TH TO MAY- 4TH AS GROUND SQUIRREL WEEK, AND TRUST THAT DURING THAT TIME THE SCHOOL CHILDREN AND ALL OTHER PERSONS WILL DO THEIR UTMOST TO RELIEVE THE COUNTRY OF ALL GROUND SQUIRREL PEST.
Wm D. Stephens
GOVERNOR
WE MUST REPENT IN HASTE THOSE COUNTY HORTICULTURAL COMMISSIONERS MEAN BUSINESS
THERE, THERE, CITELLUS DON'T CRY - WE HAVE LIVED WELL FOR LO, THESE MANY YEARS BUT CALIFORNIA SURELY DOES NOT WANT US ANY LONGER.
HOOVER WIRES:
"Hon. G. H. HECKE, State Commissioner Horticulture, Sacramento, California
"Campaign has my hearty approval as squirrels destroy vast quantities of food which might otherwise be used for support of Our Armies abroad and the Allies."
GET THE YOUNG SQUIRRELS NOW!
ASK Your County Horticultural Commissioner HOW
RODENT CONTROL DIVISION W. C. JACOBSEN SUPERINTENDENT
STATE COMMISSION OF HORTICULTURE
Sacramento G. H. HECKE, Commissioner California

FIG. 65. Poster distributed throughout California in advance of "Squirrel Week," April 29-May 4. Results secured were indeed gratifying.

horticultural commissioner of Lassen County, in commenting on the work says, "The grand total of 31,669 is very pleasing, especially when we realize that probably not more than one-half the squirrels killed have been reported."

On May 1 five field assistants were appointed by civil service examination to have charge of rodent control on state and school lands. The state had been divided into five districts with a field assistant in charge of each, as follows: Sacramento District, C. Olsen (resigned), R. E. Travis now in charge; Northern California District, A. E. Gray; North Coast District, Harley Ean (resigned), J. N. French now in charge; San Joaquin Valley District, L. S. Neville; Southern California District, A. H. Call. These men are cleaning up state lands—first, those close to agricultural lands, and second, those in more remote districts. They are assisting the county horticultural commissioners in arousing greater interest in rodent control; they are demonstrating the proper methods of control; the mixing of poisoned grain for this purpose, and the proper methods of distributing poisoned baits.

Crews working under the direction of the field assistants, operating on state and government lands, have been active in Trinity, Glenn, Tehama, Monterey, San Luis Obispo, Madera, Tulare, Riverside, San Bernardino, Los Angeles and Santa Barbara counties. The field crews of the United States Biological Survey have been active in Lake, Mendocino, Modoc, Lassen, Tulare, Kern, Merced and Santa Barbara counties. These state and government agencies working in the closest co-operation and harmony have, during the summer and fall of 1918, destroyed ground squirrels over an area of approximately 280,000 acres. That the work has been well done is assured by the number of letters of commendation received.

The Rodent Control Division, co-operating with the United States Biological Survey, has been able to purchase saccharin at considerably lower prices than those quoted by dealers, whose average price was $23.50 per pound, whereas the saccharin secured through our co-operative agreement was $5.50 per pound. These lower prices also are offered to the county horticultural commissioners as co-operators, and thus far have effected a great saving to the counties of California.

By an advantageous arrangement with the state prison at San Quentin it will be possible for the division to furnish wasteballs for use during the rainy season with carbon disulphid to county horticultural commissioners or other co-operating agencies at the very desirable figure of $2.75 per thousand. This is from $1.75 to $4.25 less per thousand than in past year offered through the retail channels of trade. Two to three million wasteballs will be available for distribution.

Last but not least, a word about the exhibits of the Rodent Control Division at the State Fair at Sacramento and the Liberty Fair at Los Angeles. The emergency appropriation by the Board of Control for the prosecution of this important work, being entirely a food conservation measure, it was considered entirely fitting and proper to make an educational exhibit illustrating by charts, etc., the tremendous amount of damage occasioned by rodents in California and other states; the best methods of control, and by habitat groups and study skins, most of the destructive rodents of California. In order that this be done

properly, Mr. J. P. Herring, taxidermist, was added to the Rodent Division staff. The habitat groups were prepared by Mr. Herring, and being the main features of interest at the exhibit, evoked much favorable comment, due to their excellent character. Live specimens of squirrels, gophers, chipmunks, hawks, etc., were on display. It was through the State Fair at Sacramento that the State Commissioner of Horticulture had endeavored for the first time to acquaint the public with the activities of this department of the state government. In addition to the rodent exhibit, the Insectary, Quarantine and Standardization divisions of the office of the State Commissioner of Horticulture exhibited excellent features at both fairs. All were of much interest to the taxpayers of the state, as was shown by the thousands that thronged the booths every day.

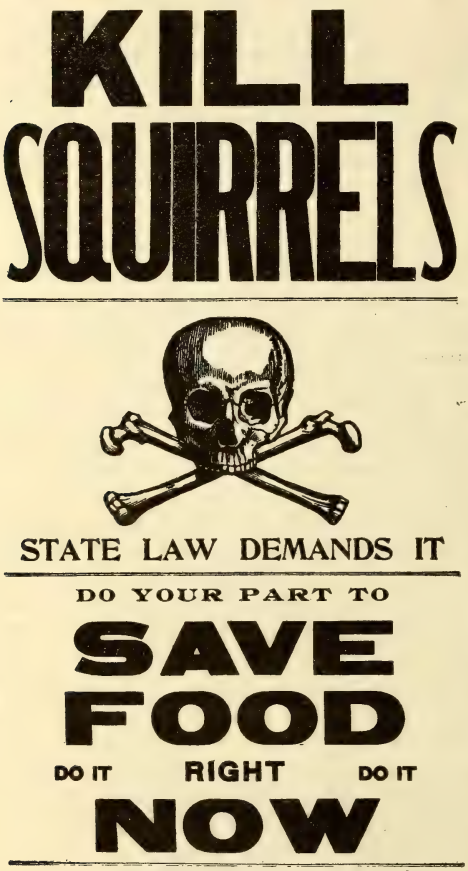


FIG. 66. Permanent poster issued by the Rodent Control Division, printed on heavy cloth, permitting its use in rainy weather without being destroyed.

It is the duty and pleasure of the Rodent Control Division at all times to assist any individual, to co-operate with any organization, and to furnish any information available on rodent control. There is a great field for operations ahead and the work hardly has been started. Only with the co-operation of the people of California can the destructive ground squirrel be eliminated and really lasting results be obtained. By the concerted effort involving every possible co-operating agency and the population of every county from Del Norte to Imperial this can be accomplished. The success of an effective squirrel campaign, with the preconceived idea in view of exterminating the ground squirrels in California, lies in the motto, "KEEP AT IT!"

## RODENT ERADICATION WORK OF THE BIOLOGICAL SURVEY IN CALIFORNIA.

By F. E. GARLOUCH.[1]

Extensive, persistent and beneficial movements ususally start from small beginnings. The economic work of the Bureau of Biological Survey, United States Department of Agriculture, is an example of this kind. From the experimental operations begun in 1887 in Iowa and Minnesota to determine the economic status of ground squirrels, gophers and certain birds with a view to testing out effective poisons and practical methods for controlling harmful species of birds and mammals, has come the popular nation-wide movement to destroy harmful rodents.

One or two reasons among several may be mentioned why this control has become necessary. Nature, when not interfered with, tends to establish a balance of numbers in the animal kingdom; but Nature has not been left undisturbed. Man's activities disarranged things. He killed off the larger animals and birds which prey upon rodents, thereby permitting them to increase out of due proportion and become a serious pest. Natural means of control have thus been reduced and it is now necessary to devise artificial means. Another factor is due to change of habits and preferences of the pests themselves. They have found cultivated grains, fruits and grasses easier to obtain and, in many cases, more to their liking than the wild foods, so they have moved in on fields of the farmer, resulting in great crop losses.

Experimental work with poisons and traps by several investigators of the Biological Survey on ground squirrels, prairie dogs, pocket gophers, and rabbits was carried on from 1887 until July 1, 1905, when by act of Congress, the Biological Survey was made a bureau and the Division of Economic Ornithology and Mammalogy was established. Since that time the economic work has been continuously and systematically going on. The first work was undertaken in California by the survey on pocket gophers in the vicinity of Banning, in Riverside County, in 1908. The following year experiments were undertaken by S. E. Piper, assistant biologist, to determine an effective method of destroying the California Digger ground squirrel. Space will not permit anything like a full discussion of all of the painstaking investigations conducted by him during the next five years. Some of the important results secured and facts learned will suffice.

Bacterial viruses were tried repeatedly but without satisfactory results. Trapping was found not to be practical on a large scale except for certain animals, and special poisons proved to be the cheapest and quickest way of obtaining desired results.

### POISONS IN GENERAL.

It may be well to state briefly here some of the general physiological effects of poisons as worked out by various investigators. The effect of a poison may be local, or remote, or the same poison may produce effects both local and remote. By local is meant that the poison directly

[1] I desire to acknowledge the great obligation to Mr. S. E. Piper and to Mr. W. B. Bell for their suggestions, additions and revision of this article.

affects the point with which it comes in contact; for instance, the irritation of mucous membranes caused by arsenic. An effect is remote when a distant part of the body is involved. A poison may be taken into the stomach, but the resultant effect may appear in the spinal cord, as in the case of strychnine. The poison has to be absorbed and carried by the blood to the part affected. Local action usually causes a slow death accompanied by intense suffering; the remote causes death more quickly without such severe pain. The latter group of poisons has proved more satisfactory for use in poisoning operations. Death in either case is caused by collapse produced by the sudden change made in the structure of the affected part, or by disruption of its natural way of functioning.

The quickness with which poisons act depends first on the poison; second, on the form and manner in which it is administered; and, third, on the individual animal itself. Naturally some poisons act more rapidly than others, but the poison may act more quickly as a gas than as a liquid or a solid; for example, carbon disulphid. Generally speaking, the more finely the poison is divided the easier and quicker its absorption and action. A small lump of phosphorus might be taken into the stomach and pass through the body without serious result, but if a very small part of that lump finely divided or in solution were taken, it might cause death very quickly. Again, the same poison varies in rapidity of action in different individuals of the same species. Usually poison acts more quickly on a young than on an old animal, on an animal in a weakened physical condition than on one that is strong, healthy, and vigorous. When taken into an empty stomach, poison acts more quickly than when received in one containing considerable food. The character and amount of the stomach contents may accelerate or retard action. A poison taken directly into the blood acts more quickly than by way of the stomach. Some poisons, if at first taken in small doses, may later be increased in amount until the dose in larger than that which is ordinarily fatal and still not cause serious results. This is true of arsenic. It is difficult to state with certainty fatal doses of any poison because of the many conditions affecting their action. Poisons properly used are certain in action and are the most reliable means of destroying rodent pests.

A few important points regarding the chief poisons now in use may be summarized as follows:

PHOSPHORUS.

*Effect*—Local in action, first causing irritation and inflammation of the digestive tract. Death may occur in the early stage of poisoning, but usually in man there is temporary recovery, followed in a few days by recurrence of the symptoms, accompanied generally by jaundice and severe abdominal pain, resulting eventually in collapse and death.

*Fatal Dose*—Minimum dose for a human being may be one-fourth to three-fourths grain.

*Advantage*—Small dose effective if given in a finely divided or soluble state.

*Objections*

1. It is slow in action.
2. It is dangerous to handle by the inexperienced because of its inflammability when exposed to air and sunlight.
3. It is no respecter of useful birds or animals, but kills all alike.

*Antidote*—For a human being, give an emetic, such as mustard in doses of 2 to 4 teaspoonfuls in a cupful of tepid water, or, better, copper sulphate in doses of 3 to 5 grains in one-half cup of water until vomiting is started. *Do not give oils or fats.* Administer 2 or 3 tablespoonfuls of hydrogen peroxide (dioxygen) to the empty stomach followed by a saline cathartic. Do not give milk under any circumstances.

ARSENIC.

*Effect*—It is both local and remote in action. It irritates the digestive tract and produces nephritis. It also slightly resembles phosphorus in its late effects.

*Fatal Dose*—For a human being, about 1.5 to 3 grains at least.

*Advantages*—

1. Inexpensive.
2. Easy to obtain, but its usefulness as a rodent poison has not been fully determined nor methods of application placed on a practical basis.

*Objections*—

1. Acid in reaction, therefore, causes souring of baits and the metallic taste is objectionable to rodents.
2. Uncertain in action.
3. Taken in large doses usually causes animals to vomit and recover.
4. In small doses develops an immunity.

*Antidote*—Give an emetic, followed by large draughts of milk.

POTASSIUM CYANIDE.

*Effect*—In some cases it may be slightly local in action but it is always remote. It acts very quickly, causing paralysis of the nerve centers, with cessation of respiration.

*Fatal Dose*—About 2.5 to 5 grains is generally accepted as the minimum required for man.

*Advantages*—

1. Inexpensive.
2. Acts quickly.

*Objections*—

1. It will not stand exposure. The effective part of the chemical compound soon escapes as a gas into the air.
2. When taken in doses that are too strong, the animal will often vomit and recover.
3. Dangerous to have about.

*Antidote*—Must be given quickly. Give strong emetic until vomiting is started. As this poison affects respiration and heart action, artificial respiration must be applied.

STRYCHNINE.

*Effect*—It is absorbed readily and carried to the spinal cord, producing clonic or tetanic convulsions, or both. Death occurs from paralysis.

*Fatal Dose*—One grain is about the fatal dose to a human being.

*Advantages*—

1. Certainty in action.
2. Antidotes simple and easy to obtain in case of accidental poisoning.
3. Small amount fatal to rodents. A much larger amount in proportion to weight required to be fatal to most game birds. Quail, grouse, and almost all gallinaceous birds are practically immune.
4. Its bitterness acts somewhat as a safeguard to accidental swallowing.
5. It is more economical than other poisons when results are taken into consideration.

*Objections*—

1. Its extreme bitterness, unless disguised, is objectionable to many animals.

*Antidote*—For a human being, give an emetic, as mustard, strong salt solution, or a large dose of a warm solution of sodium bicarbonate (baking soda). Then give milk or white of egg. Keep patient in a dark and quiet place. Call a doctor. To a dog, give emetics as above, followed by plenty of grease or lard. If a horse is found eating poisoned grain, seize the tongue and thoroughly clean the grain out of the mouth. Then drench with very strong tea, made by putting one pound of tea in one quart of boiling water, stir well and add two quarts of cold water. Follow later with a good dose of Glauber's salts to counteract the binding effect of tannin in the tea. Call a veterinarian for further treatment. The horse should be kept in a cool, quiet place.

*Kinds*—

1. Strychnine sulphate. It can be obtained either as a crystal or as a powder. It is readily soluble in hot water.
2. Strychnine alkaloid. It can be obtained either as a crystal or as a powder. It is slightly soluble in hot water, but if a little acid is added (strong vinegar will answer the purpose) it will readily dissolve to form the acetate. A given quantity of strychnine alkaloid is about 20 per cent stronger than an equal weight of the sulphate. Its bitter taste is more readily concealed in poison baits. It is more stable in combinations than the sulphate, hence is preferable for poisoning operations.

## INVESTIGATION IN CALIFORNIA.

In Mr. Piper's investigations strychnine, all points considered, proved the most practical poison, after careful comparison with those mentioned above. Such bait materials as fruits (fresh and dried), nuts, dry meals, flesh products, grasses and vegetables, were eliminated, in a long series of tests, in favor of barley grain, of the rough or shoe-peg variety. Throughout the dry season when the squirrels are storing food, this grain was found to possess marked advantages over all others. These advantages are closely related to the hardness of the grain and its close, tight-fitting husk, which the squirrel finds difficulty in removing. Strange to say, the Digger squirrel is so skillful in removing the outer hull from oats that he can eat large quantities of this grain without being killed, though the oats be poisoned in precisely the same manner as barley, a few kernels of which effect his death. On the other hand, oats are far more effective than barley for the small Oregon ground squirrel which inhabits the plains region of northeastern California.

In the early investigations on the Digger squirrels, grains were soaked or boiled in strychnine solutions with the idea of impregnating the kernels with the poison. The squirrels, however, exhibited marked objection to the bitterness of grain so treated, and no amount of sweetening, or "doctoring" covered this defect sufficiently to cause them to eat the kernels, though they hulled them out and tasted them.

The squirrels' habit of carrying grain in their cheek pouches, which is especially marked during the dry season, or when seeds are abundant, was at this time taken into consideration. It was thought that if strychnine could be held in a readily available form in a coating on the surface of the grain, sufficient of the poison would be assimilated directly from the cheek pouch to kill the animal, even though none of the grain was eaten. This became the actual basis on which has been developed one of the most successful of all rodent poisons.

In comparison with syrups, albumen, cereal pastes, gelatines and commercial gums, starch mucilage proved most satisfactory as the medium for the poison coating. It makes a very thin coating that readily liberates the strychnine into the squirrel's cheek pouches. The addition of soda bicarbonate and saccharin in the poison coating has a marked effect in delaying the bitter taste of the strychnine, so that squirrels are less likely to refuse the poisoned grain. Small amounts of heavy corn syrup and glycerin are added to the coating to prevent the grinding and dusting off of the poison which occurs when the grain becomes dry. Shellac, other resins, fats and vegetable oils were tried as coating mediums in attempts to make a rain-resistant poison that could be used effectively during the wet season of winter and early spring, but these materials do not liberate the poison freely enough to kill the animals. Moreover, the squirrels, to a great extent, cease carrying grain in their cheek pouches soon after the coming of the rainy season; instead they then hull out the kernels where the grain is found. It is evident that a satisfactory winter poison—as yet not determined—must be based on some other form of strychnine or other peculiarity of the animal.

An effective poison was only half the battle. The method of distributing it is quite as important. The first impulse in distributing poisoned grain, still followed by many, was to place it in the holes or in a small heap at the very entrance of the squirrel's burrow. But squirrels do not look for food in these locations, and much of the poisoned grain is lost by being covered by the animal running over it. Nature did not drop the squirrel's food into the burrows nor place it in neat little piles in front of them; she scattered it in locations not always near the burrows. Accordingly, the poisoned grain is now scattered on clean areas within three to ten feet of the burrows, around trees or rockpiles, along squirrel trails and in places where the animals feed.

The standardized formula resulting from these investigations, and the method for applying it, have been of immense economic value to California. Used in the dry season and properly distributed, the poison is entirely reliable. If prebaiting with clean, unpoisoned barley be practiced in advance of poisoning, the squirrel pest can be practically eradicated by a single poison treatment in any given locality. The common mistake is in attempting to use the poison during the wet season, when results are less certain, though even under such conditions it is among the most effectual of strychnine preparations. In general use in the state for the past six or seven years, it has very largely replaced the use of proprietary poisons at a small fraction of the cost of the latter. In clearing the squirrel pest from valuable agricultural areas, from irrigation systems, from nut groves and grainfields, the aggregate saving to the state must be expressed in millions.

Carbon disulphid has proved valuable during the wet seasons, especially for completing extermination of ground squirrels following the use of the poisoned baits. It is very volatile and explosive, so should be handled with care. There are two ways of using it, either by using a pump which forces the gas into the burrow, or by saturating an absorbent ball of some sort with the liquid and dropping it into the burrow. The latter method is more commonly used. A convenient

absorbent ball about the size of a hen egg is made of jute wrapped in cheesecloth. Place about 65 of these in a vessel and pour over them one gallon of the carbon disulphid. As the liquid is very volatile, it is necessary to have a lid on the vessel which fits tightly. Drop one of these saturated balls into each burrow and after two minutes light with a match or torch, being careful to keep the face away from the opening. Then tightly close up the burrow. The cost of treating an area the first time with the carbon disulphid is greater than with the poisoned grain; however, the percentage of animals killed is usually higher, which offsets to some extent the difference. It is good for follow-up treatment after using poisoned grain. A combination of the two methods is often cheaper than either used alone.

Similar investigations have been made by the Biological Survey in California on the problems of controlling pocket gophers, jack rabbits and other destructive rodents, and reliable methods have been devised. In the case of pocket gophers, the main difficulty lay in placing the poison where the animal would find it. A close study of the habits of the animal and its underground home has resulted in a method so practical and effective that these costly pests can be quickly eliminated from any given area.

### RECORD OF OPERATIONS IN CALIFORNIA.

Minor operations against squirrels, gophers and seed-eating rodents were carried on in California from 1911 through 1912 on the Tahoe, Santa Barbara, Angeles and Shasta national forests. The season of 1913 marks the beginning of the extensive work in this state against ground squirrels on the Monterey, San Benito, Santa Barbara and Sequoia national forests. From this time on to the present season the operations have steadily grown in extent until some of the forests have now been entirely covered once and parts retreated a second and a third time to complete extermination. The California forest has been practically entirely treated, also the more heavily infested areas of the Modoc, Sierra, Sequoia, and Monterey forests. Extensive work on the Santa Barbara forest and the outlying public lands in San Luis Obispo County are planned for the coming season.

The total acreage treated for ground squirrels on the various forests and public lands in California up to the beginning of the 1918 season is as follows:

| | Acres |
|---|---|
| California National Forest | 446,385 |
| Modoc National Forest | 53,000 |
| Monterey National Forest | 37,000 |
| Sequoia National Forest | 93,645 |
| Sierra National Forest | 7,607 |
| Santa Barbara National Forest | 11,525 |
| Tule Indian Reservation | 3,700 |
| Public Lands in San Benito County | 4,610 |
| *For Pocket Gophers.* | |
| Sequoia National Forest | 1,280 |
| Tahoe National Forest | 1,100 |
| | 659,852 |

The work during the 1918 season has been outside the forests on public and Indian lands adjacent to farming land. The acreage treated up to October 1 is as follows:

*Indian Lands.*

| | Acres |
|---|---|
| In Mendocino County | 36,495 |
| In Modoc County | 640 |
| In Tulare County | 3,100 |
| In Lake County | 485 |
| | 40,720 |

*Public Lands.*

| | Acres |
|---|---|
| In Mendocino County | 5,860 |
| In Shasta County | 1,160 |
| In Modoc County | 20,955 |
| In Lassen County | 26,685 |
| In Tulare County | 8,600 |
| In Kern County | 12,299 |
| In Merced County | 18,490 |
| In Santa Barbara County | 5,875 |
| | 99,924 |

Acreage, as shown by reports not yet complete, treated in co-operation with the Rodent Control Division of the State Commission of Horticulture, in which the Bureau of Biological Survey furnished the poison and the state provided the labor:

| | Acres |
|---|---|
| In San Luis Obispo County | 13,600 |
| In Glenn County | 8,000 |
| In Tehama County | 5,619 |
| | 27,219 |

Total acreage treated to destroy ground squirrels and pocket gophers in California ---------- 827,715

The first operations on the forests were on those areas known to be heavily infested, the open meadows and glades. It was found, however, that the areas were soon reinfested because of the migratory habits of the squirrels. They moved readily into new territory where feed was found to be better than that in which they happened to be. To prevent reinfestation due to this natural habit of the animals, it has been necessary to treat both the open and timbered areas of the forests, even though the infestation might be very light in the latter. A few breeding animals left soon reinfest a vicinity, as they are very prolific. It is quite necessary to kill the last squirrel.

The infestation of the forests averaged about five burrows to the acre. The poisoning crews consist of two to four men who work on horseback wherever possible. They have bags of poison hanging from the saddle horn and ride abreast about 25 yards apart, treating all the land that is infested as they go. The thick brushy belt is not infested with squirrels except along the edges. In brushy country one man averages about 100 acres per day.

It was noted that the treated land along the borders of the forests adjacent to untreated private lands soon became reinfested. This fact, together with the increasing number of requests for assistance from ranchers in California who knew of the work on government lands, led the bureau into the broader field of giving assistance to the farmers and helping them to conserve and increase the food supply so greatly needed owing to war and general commercial demands by organizing systematic community and county campaigns, using the most effective methods under competent direction and supervision.

A study of conditions under which ranchers were fighting the squirrels and methods employed by them revealed these problems:

1. Lack of an effective cheap poison.
2. Lack of an effective method of distributing poisons.
3. Lack of organization to secure concerted co-operation of every landowner whose lands were infested.
4. Lack of knowledge of the methods being successfully employed by the government agencies working on the problem.
5. Failure to realize the great damage and loss caused by rodent pests.
6. Lack of a desire to exterminate the pests on the part of the majority of the ranchers and discouragement on the part of the minority who were faithfully fighting them.

To meet these conditions the Biological Survey began in the spring of 1917 the county educational campaigns, co-operating with the county commissioners of horticulture and county farm bureaus. The aim of these was to meet the ranchers directly and acquaint them with the habits of the rodent pests and the great damage that they are doing throughout the state; to give information as to cheap and effective poisons and the most successful methods of distribution; and, last but not least, to instil a desire into the mind of the ranchers to eradicate the squirrel and gopher pests. It was strongly recommended that the counties prepare under proper supervision their own poisoned grain according to the Biological Survey formula and sell it direct to farmers at cost. The counties so doing have saved the farmers a large amount of money in the cost of poison. About 300 tons have been mixed and sold by the various counties in the state since August 1, 1917.

In 1917 fifteen county campaigns were held and during the present year they were continued in co-operation with the Rodent Control Division of the State Commission of Horticulture. Those counties in which the campaigns have been followed up with a definite, concrete plan embodying thoroughness, persistency, and united action, are making a successful fight against the pests.

In some communities in which the government crews have been working this season on public lands, private landowners have co-operated heartily and a saving in grain, bean, alfalfa, fruit, and other important agricultural crops, valued at many thousands of dollars, has resulted. Reports from the rangers on the forests where work has been carried on for a year or more show a noticeable increase in the carrying capacity of the range, estimated at from 15 per cent to 25 per cent. All these reports plainly indicate that the effort is not in vain.

It is planned to continue these organized campaigns on a greatly enlarged scale during the coming year, and it is now evident that by persistent, united effort on the part of federal, state, county and other local organizations co-operating with the landowners, crops can be effectively protected from the depredations of these serious agricultural pests and the production of food in California greatly increased.

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TIMELY TOPICS DURING SQUIRREL WEEK, APRIL 29–MAY 4, 1918.

Kill the ground squirrel NOW and AT ALL TIMES.

The United States Government is controlling the ground squirrel on government lands, the national forests, etc. The State Rodent Control Division is doing it on state lands and the individual must do it on his property to complete the link which means absolute control of this pest.

The ground squirrel is a voracious feeder and reproduces rapidly.

The usual annual increase of a pair of ground squirrels consists of one litter of from five to nine young, so that one breeding female killed before the young are able to take care of themselves is equal to the destruction of from six to ten squirrels later in the season.

Unity of action is needed. Do not wait for the other fellow, but get to work at once. He will fall in line.

The control of this pest means food conserved for ourselves and our allies, and more, it means increased production.

The control of ground squirrels has been attempted for many years, but never before has there been such a concerted effort made to exterminate them. The campaign NOW ON has the support and indorsement of every organization and agency in California today, interested in food conservation and increased food production.

The depredations of the ground squirrel in California, annually, will support several thousand families at an average annual expense for food of $500.

The ground squirrel destroys grain, fruit and nuts; undermines bridges, railroad embankments and irrigation canals and spreads disease. It is therefore a most undesirable citizen.

The law says kill them, but do it voluntarily.

The funeral of one pioneer we all are glad to attend, the ground squirrel.

He destroys $30,000,000 worth of products annually.

This amounts to $55 each for every school child in California.

In some localities the ground squirrel reduces the grain yield 50 per cent.

The United States Department of Agriculture, through its Bureau of Biological Survey, has set aside a fund of approximately $10,000 to be used solely upon national forests and government lands.

The United States Public Health Service has charge of operations to check the spread of bubonic plague, carried by the ground squirrel flea, and is thereby safeguarding the health of everyone in California.

The horticultural commissioner in each county is assisting the farmer by compelling the landowners, who in past seasons have refused to co-operate, to clean up.

The Agricultural Extension Division of the University of California, with the well organized Farm Bureau System, has pledged co-operative support through the farm advisers.

The United States Forest Service will aid every county horticultural commissioner in the work of eradicating squirrels within the national forests by the assistance of forest rangers.

The State Council of Defense and the Food Administration have lined up to back the movement.

Many chambers of commerce and boards of trade have guaranteed full backing to the horticultural commissioners in their worthy work.

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## APPENDIX.

### DIRECTIONS AND FORMULAS FOR DESTROYING NOXIOUS RODENTS.

[NOTE.—The following formulas and directions are adapted from the various publications, reports, contributions, and yearbook reprints of the Bureau of Biological Survey, U. S. Department of Agriculture.]

### CAUTION.

*All poison containers and uncleaned utensils, used in the preparation of poisons, should be kept PLAINLY LABELED and OUT OF REACH of children, irresponsible persons and livestock.*

### DIRECTIONS FOR DESTROYING CALIFORNIA, OR "DIGGER" GROUND SQUIRRELS.

| | |
|---|---|
| Barley, recleaned grain | 16 quarts |
| Strychnin (powdered alkaloid) | 1 ounce |
| Bicarbonate of soda (baking soda) | 1 ounce |
| Saccharin | 1/10 ounce |
| Heavy corn sirup | ¼ pint |
| Thin starch paste | ¾ pint |
| Glycerin | 1 tablespoonful |

In a clean vessel mix thoroughly 1 ounce of powdered strychnin (alkaloid), 1 ounce of common baking soda, and 1/10 ounce of saccharin. Crush all lumps of the soda with mixing spoon. To this add ¼ pint of heavy corn sirup and stir thoroughly to a smooth, creamy paste free from lumps. Over this pour ¾ pint of thin hot starch paste and stir well. (The starch paste is made by dissolving 1 heaping tablespoonful of dry gloss starch in a little cold water which is then added to ¾ pint of boiling water. Boil and stir constantly until a clear thin paste is formed.) Add the tablespoonful of glycerin and stir thoroughly, making sure that none of the heavy sirup paste still sticks to the bottom of the container. Pour this mixture over 16 quarts of good cleaned barley and mix well so that each grain is coated.

For mixing small quantities an ordinary galvanized wash tub is convenient. For larger quantities a tight smooth box may be used, and the mixing may be done with a spade.

Each quart of the poisoned grain is sufficient for 40 to 50 baits. This quantity SCATTERED along squirrel trails, or on clean, hard places on the surface about the holes, will not endanger stock.

N. B.—Strychnin in any form other than the powdered strychnin alkaloid is not effective in the above formula.

*Why Barley Is Used.* Barley is recommended, in poisoning with strychnin, because its roughness holds the poisoned coating better and it is usually more attractive to squirrels and far less likely to be eaten by birds than wheat. The above formula makes an entirely coated grain which is more efficient than a soaked grain and kills squirrels more quickly so that they are much more likely to die above ground where they can be seen. This is due largely to the squirrels' habit of gathering grain and carrying it in their cheek pouches. The cheek pouches are within the mouth and are lined with mucous membrane which readily absorbs the poison from the coated grain. When absorbed by the cheek pouches it requires only about one-fifth as much strychnin to kill the animal as it does when taken into the stomach.

*Distribution of Poisoned Grain.* The poisoned grain should be well scattered (*not placed in piles*) along the squirrel trails and clean hard places on the surface of the ground about the burrows. It should *not* be placed down in the burrows, except when used near farm buildings or poultry yards, upon the mounds too close to mouth of burrows, nor in grassy places. If well scattered it will not endanger livestock and the squirrels are not so apt to hull it.

*Poisoning With Green Barley Heads.* In selecting barley heads for this purpose the grain should be in the paste or ripening stage and the long beards should be snipped off with scissors. They should then be immersed in a solution made by dissolving one ounce of strychnin *sulphate* in a gallon of boiling water to which a

NOTE.—To adapt the above formula for use in destroying the Oregon ground squirrel or "Picket Pin," 20 quarts of recleaned oats should be substituted for the 16 quarts of whole barley.

teaspoonful of saccharin has been added. When the solution is cool as many trimmed barley heads should be put into it as the liquid will cover and they should be allowed to soak for twenty-four hours. The poisoned heads should be distributed in the early morning so that they may be eaten before drying. Two or three should be placed near each hole inhabited by adult squirrels and six to eight in the case of families of young as each squirrel is likely to eat an entire head before the poison takes effect.

*Caution*—Care should be taken in distributing in places accessible to stock, particularly if feed is scarce.

*Poisoning Fresh Fruits, Etc.* Strychnin *sulphate* is freely soluble in fruit juices and these seem to conceal, to some degree at least, the bitterness of the strychnin. Cull fruits of various kinds have been used successfully. Oranges cut in halves, watermelon rinds cut into pieces about three inches square and poisoned by sprinkling with powdered strychnin sulphate make excellent baits. It seems to be the moisture contained in these baits that makes them particularly acceptable during the excessively dry season. Powdered strychnin inserted into prunes and raisins by means of a knife blade is very effective.

*Carbon Disulphid.* Carbon disulphid is one of the best agents to be used as a follow-up method to get the squirrels that fail to take poisoned grain. It should only be used when the soil is sufficiently wet to keep the gas from escaping.

*Method of Application.* Balls made of cotton waste, old sacking or other absorptive material should be made large enough to hold at least two ounces of the fluid when saturated. Ready-made balls can be purchased from firms selling carbon disulphid. A number of these balls are placed in a covered pail to prevent the gas from escaping and over these is poured sufficient carbon disulphid to cover entirely after saturation.

*To Load the Burrows* the saturated balls are taken from the pail by means of a wire hook and placed into the burrows as far down as possible. It is well to load all holes in a colony before exploding. This will overcome the danger of being burned when loading a communicating burrow. The explosion of the gas is recommended because vaporization under normal conditions would not occur so quickly.

When the gas in the burrow is exploded a chemical reaction takes place which produces a volume of gas three times that of the carbon disulphid itself. The gases produced in addition to carbon dioxide are carbon monoxide and sulphur dioxid which are in themselves quite poisonous. The explosion forces these gases to the farthest recesses of the burrow. After exploding, the mouth of the burrow should be stopped up with a clump of earth or sod well mounded and tamped.

FORMULA[1] FOR POISONING CALIFORNIA DIGGER GROUND SQUIRRELS.

| | |
|---|---|
| Whole barley (recleaned grain) | 1 sack or 80 quarts |
| Strychnin (powdered alkaloid) | 5 ounces |
| Baking soda (bicarbonate of soda) | 5 ounces |
| Heavy corn syrup | 1 pint |
| Thin starch paste | 3 pints |
| Saccharin | ½ ounce |
| Pure glycerin | 5 tablespoons |

[1]*Quantities for a one-sack mixing.*

Mix the strychnin, soda, and saccharin together and crush all lumps with the mixing spoon. Add the corn sirup and stir to a smooth creamy paste. Add the starch solution and stir well to free all of the sirup paste that may have adhered to the bottom of the container. Lastly add the glycerin. The above mixing ought to be done in a vessel *no* smaller than a small dishpan.

Pour the mixture over the amount of grain called for and *mix thoroughly* until *every* grain is coated. If mixed in a large box, with shovels, the batch should be turned back and forth at least 8 times.

FORMULA[1] FOR POISONING "CALIFORNIA DIGGER GROUND SQUIRREL."

| | |
|---|---|
| Whole barley (recleaned) | 320 quarts or 80 gallons |
| Strychnin (powdered alkaloid) | 20 ounces |
| Bicarbonate of soda (baking soda) | 20 ounces |
| Heavy corn sirup | 2 quarts |
| Starch paste (medium consistency) | 3 quarts |
| Glycerin | 20 tablespoons |
| Saccharin | 2 ounces |

[1]*For large mixings, 4 sacks.*

Mix the strychnin, soda and saccharin together in dry form and crush all lumps of the soda. Pour over the above the quantity of the sirup called for and stir to a smooth paste free of lumps. The few lumps of soda remaining will be dissolved when the hot starch paste is added. About a quarter pound of starch will make sufficient starch paste made as per smaller formula. Starch paste is added to the sirup paste and stirred until the sirup paste is all free from container. Glycerin can be added last. For a batch this size the solution should be made up in a large dishpan. Pour mixture over correct amount of grain and *mix thoroughly* until *every* grain is coated. A batch of this size may conveniently be mixed on a smooth, concrete floor, or in a box specially made 6 feet long by 4 feet wide by 1 foot high. (See fig. 52.)

DIRECTIONS FOR DESTROYING POCKET GOPHERS.

Pocket gophers are readily caught in any one of several makes of special traps commonly on the market, and a few of these suffice to keep small areas free of the pests. For ridding alfalfa fields, orchards, and long stretches of ditch embankments of them, a very successful and much more practical method is to poison them by use of baits of sweet potato or of parsnips placed in their underground runways.

The baits should be cut about 1 inch long and ½ inch square, and washed and drained. From a pepper box slowly sift ⅛ ounce of powdered strychnin (alkaloid) and 1/10 of this quantity of saccharin (ground together in a mortar) over about 4 quarts of the dampened baits, stirring to distribute the poison evenly.

The runways, which are usually 4 to 8 inches beneath the surface, can be located by means of a probe made of any strong handle an inch in diameter and 36 inches long. One end should be bluntly pointed. Into the other should be fitted a piece of ⅜-inch iron rod, protruding about 12 inches and bluntly pointed. A foot rest aids in probing in hard soils. By forcing down the iron rod near gopher workings, or a foot or two back of fresh mounds, the open tunnel can be felt as the point breaks into it. The blunt end of the instrument is then used carefully to enlarge the hole, a bait or two is dropped into the run, and the probe hole closed.

One soon becomes expert in locating the runs, and a man can treat 300 to 500 gopher workings in a day. Baits need be placed at only two points in each separate system of 10 to 30 mounds, which is usually the home of a single gopher. Experience has shown that baits placed fairly in the open runs invariably kill the gophers. The method has found great favor wherever introduced.

DIRECTIONS FOR POISONING MEADOW AND FIELD MICE.

Meadow mice are readily destroyed by means of poisoned baits placed in their trails or shallow tunnels, which can be easily located by probing with a bluntly pointed stick. Depredations by meadow mice may be greatly lessened, and serious outbreaks prevented by clean cultivation, the elimination of old fence rows, and prompt burning of weeds and other trash.

*Dry Grain Formula.* Mix thoroughly 1 oz. powdered strychnin (alkaloid), 1 oz. powdered bicarbonate of soda, and ½ oz. (or less) of saccharin. Put the mixture in a tin pepper box and sift gradually over 50 lbs. of crushed wheat, or 40 lbs. of crushed oats, in a metal tub, mixing the grain constantly so that the poison will be evenly distributed.

*Wet Grain Formula.* Dissolve 1 oz. of strychnin (sulphate) in 2 qts. boiling water. Dissolve 2 tablespoonfuls of laundry starch in ½ pint of cold water. Add the starch to the strychnin solution and boil for a few minutes, until the starch is clear. Pour the hot starch over 40 lbs. of oats in a metal tub and stir thoroughly. Let the grain stand overnight to absorb the poison.

The poisoned grain prepared by either of the above formulas is to be distributed over the infested areas, not more than a teaspoonful at a place, care being taken to put it in the mouse runs and entrance to burrows.

*Alfalfa Formula.* One ounce of strychnin (sulphate) dissolved in 2 gallons hot water, to 30 lbs. alfalfa hay, previously moistened, was successfully used to destroy meadow mice in Nevada, during the serious outbreak of the animals in 1907-1908. The bait, distributed in small quantities at a place, was very effective against the rodents and did not endanger birds.

*Potato Formula.* Poisoned sweet potato baits are very effective for both meadow and pine mice. Cut sweet potatoes into pieces about the size of grapes. Place 3 quarts of these cut baits in a pan or bucket, and from a tin pepper box slowly sift

over them ⅛ ounce powdered strychnin mixed with an equal quantity of baking soda, stirring constantly so that the poison is evenly distributed. Poison should be applied as soon as the potatoes are cut, and bait should be put out while fresh.

The bait, whether grain or potatoes, may be dropped into the mice tunnels through the natural openings, or through holes made with broom handle or other stick.

### METHODS FOR DESTROYING JACK RABBITS.

Rabbits may be destroyed best by poisoning or driving, and these methods to be fully effective in any given district must be applied co-operatively.

In giving methods for destroying jack rabbits, it must be admitted that no specific control has been developed and results can be expected only after the trial of more than one type of procedure.

In poisoning jack rabbits, feeding grounds or runways ought to be definitely located. Moist poisoned alfalfa leaves have often proved very effective in the fall when natural feed has dried up. When rabbits are feeding on alfalfa crowns after the last fall cutting or after pasturing, small handfuls of the leaves are readily taken by rabbits. Drags in plowed land will often create a runway in which the baits can be laid.

*The Alfalfa Formula.* Dissolve 1 oz. of strychnin sulphate in 2 gallons of hot water and sprinkle over 10 lbs. of dry alfalfa hay leaves. Well formed leaves should be used. No dust or sticks should be mixed in with them. They can be threshed out of stacked or baled hay very easily on a large piece of canvas. Mix the leaves thoroughly until all the moisture is absorbed. The poisoned leaves should be distributed in small handfuls in lines a few feet apart across portions of the field where observations show the rabbits to be feeding; stock should be excluded. In localities where alfalfa is not raised, grain heads may be substituted.

*Poisoned Oats.* Mix thoroughly 1 oz. powdered strychnin (alkaloid) and 1 oz. common baking soda. Dissolve 1 heaping tablespoonful of laundry starch in a little cold water, and add 1 quart boiling water. Boil and stir until thin clear paste is formed. Slowly sift mixture of strychnin and soda into starch paste, stirring constantly until it becomes a smooth creamy mass. Add ⅛ oz. of saccharin and stir thoroughly. Pour this mixture while still hot, over 12 quarts of good oats, and mix until all the grain is coated. A good tablespoonful makes a single bait.

Partly ripened or ripe heads of barley and wheat soaked in a sweetened solution of strychnin or coated with the starch-strychnin paste, just described, have also proved effective baits for rabbits, but care must be exercised in using them, as they are likely to be eaten by livestock.

*Poison Wash for Fruit Trees.* Dissolve 1 oz. of strychnin (sulphate) in 3 quarts of boiling water. Dissolve ½ pound of laundry starch in 1 pint cold water, stirring thoroughly. Pour the starch into the vessel containing the strychnin, and boil the mixture a short time until the starch is clear. Add 6 oz. of glycerin and stir. When mixture is cool enough apply to tree trunks with a paint brush. This method has proved effective in saving trees from jack rabbits and is recommended for trial.

During the dry season in California melons and cull fruits have often proved effective. Watermelon cut into portions, or left almost whole, with a slice out of one side, can have the cut portions rubbed with powdered strychnin sulphate, or incisions may be made into which crystals of strychnin sulphate are introduced. Good results have been reported from this.

Jack rabbits are often found where more or less alkali exists. If not the case an ounce of salt ground together in a mortar with 1/12 ounce of powdered strychnin (alkaloid) may do good work. To prevent stock from taking it, the mixture may be introduced into inch holes bored into short blocks of wood. These can be placed near feeding grounds or spots where a pile of hay has been placed to attract the rabbits.

### DIRECTIONS FOR POISONING AND TRAPPING RATS AND MICE.

One of the cheapest and most effective poisons for rats and mice is *barium carbonate.* This mineral has the advantage of being without taste or smell. It has a corrosive action on the mucous lining of the stomach and is dangerous to larger animals if taken in sufficient quantity. In small doses fed to rats it would be harmless to domestic animals. Its action upon rats is slow, and if exit is possible

the animals usually leave the premises in search of water. For this reason the poison may, frequently, though not always, be used in houses without disagreeable consequences.

*Barium carbonate* may be fed in the form of dough composed of four parts of meal or flour and one part of the mineral. A more convenient bait is ordinary oatmeal with about one-eighth of its bulk of the mineral mixed with water into a stiff dough. A third plan is to spread the barium carbonate upon fish, toasted bread (moistened) or ordinary bread and butter. The prepared bait should be placed in rat or mice runs, about a teaspoonful at a place. If a single application of the poison fails to kill or drive away all rats or mice from the premises, it should be repeated with a change of bait.

*Strychnin sulphate* is too rapid in action to make its use for rats or mice desirable in houses, but elsewhere it may be employed effectively. Strychnin sulphate is the best form to use. The dry crystals may be inserted in small pieces of raw meat, sausage, or toasted cheese and these placed in rat or mice runs or burrows; or oatmeal may be moistened with strychnin sirup and small quantities laid in the same way.

Strychnin sirup is prepared as follows: Dissolve a half ounce of strychnin sulphate in a pint of boiling water; add a pint of thick sugar sirup and stir thoroughly. A smaller quantity may be prepared with proportional quantity of water and sirup. In preparing the bait it is necessary to moisten all the oatmeal with the sirup. Wheat and corn are excellent alternative baits. The grain should be soaked over night in the strychnin sirup.

*Arsenic* is probably the most popular of the rat poisons, owing to its cheapness, yet experiments prove that, measured by results obtained, arsenic is dearer than strychnin. Besides, arsenic is extremely variable in its effect upon rats, and if the animals survive a first dose it is very difficult to induce them to take another.

*Powdered white arsenic* (arsenious acid) may be fed to rats and mice in almost any of the baits mentioned under barium carbonate and strychnin. It has been used successfully when rubbed into fresh fish or spread on buttered toast. Another method is to mix twelve parts by weight of corn meal and one part of arsenic with whites of eggs into a stiff dough.

An old formula for poisoning rats and mice with arsenic is the following: Take a pound of oatmeal, a pound of coarse brown sugar, and a spoonful of arsenic. Mix well together and put the composition into an earthen jar. Put a tablespoonful at a place in runs frequented by rats and mice.

*Poison in poultry houses.* For poisoning rats in buildings and yards occupied by poultry the following method is recommended: Two wooden boxes should be used, one considerably larger than the other and each having one or more holes in the sides large enough to admit rats. The poison bait should be placed on the bottom and near the middle of the smaller box, and the larger box should then be inverted over it. Rats thus have free access to the bait, but fowls are excluded.

*Trapping.* Owing to their cunning it is not always easy to clear rats from premises by trapping; if food is abundant it is impossible. A few adults refuse to enter the most innocent-looking trap. And yet trapping, if persistently followed, is one of the most effective ways of destroying the animals.

For general use the improved modern traps with a wire fall released by a baited trigger and driven by a coiled spring have marked advantages over the old forms, and many of them may be used at the same time. These traps, sometimes called "guillotine" traps, are of many designs, but the more simply constructed are preferable. Probably those made entirely of metal are best, as they are more durable. Guillotine traps should be baited with small pieces of sausage or fried bacon. Other excellent baits for rats are oatmeal, toasted cheese, toasted bread (buttered), fish, fish offal, fresh liver, raw meat, pine nuts, apples, carrots, and corn, and sunflower, squash, or pumpkin seeds. Broken fresh eggs are good bait at all seasons, and ripe tomatoes, green cucumbers, and other fresh vegetables are very tempting to the animals in the winter.

When rats are abundant, the large *French wire cage traps* may be used to advantage. They should be made of stiff wire, well reinforced. Cage traps may be baited and left open for several nights until the rats are accustomed to enter them to obtain food. They should then be closed and freshly baited, when a larger catch may be expected, especially of young rats. It is better to cover the trap than to leave it exposed. A short board should be laid on the trap and an old cloth or bag or bunch of hay or straw thrown carelessly over the top. If a single rat is caught it may be left in the trap as a decoy to others.

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### DIRECTIONS FOR POISONING COYOTES.

In poisoning coyotes it should be borne in mind that the animals are of more than ordinary cunning. Their ability to detect the whereabouts of a trap or the presence of poison in bait is remarkable. Great care should be taken in preparing the bait to avoid human scent, for the coyote regards man as his worst enemy. In handling baits do not touch them with bare hands, but use a pointed stick or wooden forceps.

To prepare poisoned bait place 3 grains of strychnine in a capsule and insert it into a piece of suet or cow's udder about the size of an English walnut, being careful to remove all strychnine from outside the capsule. Strychnine is very bitter and if not put into capsules will be detected as soon as taken into the mouth, and the animals, becoming suspicious, will not swallow the bait, especially if very much poisoning has been done in the neighborhood. Baits should be allowed to stand in a wooden bucket about 48 hours before using to make sure that no human scent remains.

Coyotes can best be attracted to these small baits by dragging a piece of meat behind a saddle horse over foothills and across trails where the animals come from the mountains to the valleys for food and water, and then dropping the baits along the path thus made. As the animals cross the path they will follow it and pick up and swallow the poisoned baits, as their attention is on the scent of the meat drag.

Never poison a carcass, but wait until coyotes have eaten half or more than half of the flesh, then place poisoned baits around the carcass, from 20 to 30 feet away.

As coyotes are very fond of fruit, dried figs and prunes make good bait. Unless an attractive lure is placed near the baits to keep the animals busy until the strychnine takes effect, they may get away and go a long distance before dying, as the capsule has to dissolve to free the poison.

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